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ABSTRACT

The design, implementation, and evaluation of instructional radio used to teach primary school mathematics in rural Nicaragua is described in detail. The purpose of this Agency for International Development (AID) research and development project has been to demonstrate that rural school children can receive consistently high quality instruction in mathematics by radio. The first- and second-grade mathematics achievement scores reported indicate that the methods used have significantly improved radio's performance as an instructional medium. An extensive analysis of data collected and its interpretation is reported. (MP)

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# THE RADIO MATHEMATICS PROJECT:

## NICARAGUA 1976–1977

*Edited by*

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INSTITUTE FOR MATHEMATICAL STUDIES
IN THE SOCIAL SCIENCES
STANFORD UNIVERSITY

*Stanford, California*

*1978*

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# CONTENTS

FOREWORD xi

*Barbara Searle, Patrick Suppes, and José González*

*Chapter 1.* INTRODUCTION 1

*Jamesine Friend, Vitalia Vrooman, Norma Guadamuz, Juan José Montenegro, and Barbara Searle*

*Chapter 2.* THE SECOND–GRADE INSTRUCTIONAL PROGRAM 7
- 1. Development of the Second-grade Instructional Program 9
  - Instructional Methods / 10
  - The Curriculum / 12
  - The Lesson Structure / 20
- 2. Evaluation of the Second-grade Program 27
  - Summative Evaluation Design / 27
  - Evaluation Results / 27
  - Comparison of Radio and Nonradio Urban Students / 31
- 3. Comparison of Programs for Grades 1 and 2 31
  - Purposes of the Worksheet / 32
  - Other Differences / 34
- References 35
- APPENDIX A: Exercise Classes for Second Grade, 1976 36
- APPENDIX B: Radio Mathematics Project: Lesson 171 44
- APPENDIX C: Posttest Scores for Experimental, Control, Experienced, and Nonexperienced Students 80

*Barbara Searle, Paul Matthews, Patrick Suppes, and Jamesine Friend*

*Chapter 3.* FORMAL EVALUATION OF THE 1976 FIRST–GRADE INSTRUCTIONAL PROGRAM 97
- 1. The Radio Instructional Program 97
- 2. The Traditional Instructional Program 100
- 3. Design and Sampling Procedures 101
- 4. Mathematics Achievement Tests 102
  - Pretest / 102

Posttest / 103
Test Administration / 104
5. Data Analysis 105
6. Results 107
Sample Sizes for Pretest and Posttest / 107
Pretest Results / 107
Matrix-sampling Analysis of Posttest / 108
Regression Analysis of Posttest / 109
Item Analysis of Posttest / 116
7. Conclusion 117
References 118
APPENDIX A: Pretest and Posttest Scores for Experimental and Control Students 119

*Klaus Galda and Alicia de Quintanilla*
*Chapter 4.* WEEKLY TESTS 125
1. Administration of Tests 125
2. Construction of Tests 126
Selection of Topics to Be Tested / 126
Selection of Test Items / 128
3. Examples from Two Test Classes 130
4. Summary 134
APPENDIX A: Test Classes used in 1977 Third-grade Weekly Tests 135

*Thomas Tilson and Barbara Searle*
*Chapter 5.* AN ASSESSMENT OF TEACHER ATTITUDES 143
1. Development of the Questionnaire 144
2. Description of the Teacher Population 146
3. Incomplete Sentences 149
4. Agree-disagree Statements 151
Scoring Procedure / 151
Attitudes Assessed / 152
Results / 157
5. Relationship Between Teacher Characteristics and Responses 159
6. Conclusion 161
APPENDIX A: Teacher Questionnaire 163

*Thomas Tilson*
*Chapter 6.* AN OBSERVATION STUDY IN FIRST-GRADE CLASSROOMS 177
1. Description of the Study 178
2. Methodology 181
3. Results 182
    Radio Lessons / 183
    Teaching With and Without Radio: Some Comparisons / 190
    Correlations Between Classroom Variables and Student Achievement / 193
    Development of the Radio Programs: Classroom Activities During the Early and Late Broadcasts / 194
4. Conclusions 195
References 196

*Dean T. Jamison*
*Chapter 7.* RADIO EDUCATION AND STUDENT REPETITION IN NICARAGUA 199
1. Previous Evaluations 200
2. The Model and Data 203
    The Model / 203
    The Data / 205
3. Results 207
    Determinants of Student Performance / 208
    Determinants of Demand for Schooling / 212
4. Economic Implications 216
5. Conclusions 219
References 219

*Barbara Searle, John Sheehan, José González, and Edward George*
*Chapter 8.* PATTERNS OF STUDENT PROMOTION AND WASTAGE FOR NICARAGUAN FIRST-GRADE STUDENTS 223
1. Description of the Nicaraguan Setting and the Data Base 224
    The Nicaraguan Setting / 224
    Selection of the Samples / 225
    School Variables / 227
    Teacher Variables / 228
    Student Variables / 231
2. The 1974 First-grade Student Data 233

Patterns of Student Flow / 233
Relation Between Flow Outcomes and Student Variables / 238
Relationships Among Student Variables / 247
Regression Analysis of Determinants of Passing / 24

3. The 1975 First-grade Student Data 253

Patterns of Student Flow / 253
Comparison of Radio and Traditional Students / 255

4. Summary and Discussion 258

Patterns of Flow / 258
Nonrepeaters and Repeaters / 260
Rural and Urban Students / 260
Radio and Traditional Students / 261

References 261

*Stuart Wells and Steven Klees*

*Chapter 9.* EDUCATION DECISIONS AND COST ANALYSIS FOR THE RADIO MATHEMATICS PROJECT IN NICARAGUA 263

1. The Educational System of Nicaragua and the Radio Mathematics Project 265
2. Cost Analysis for Decisions 267

Description of the Cost Methodology / 267
Education Decisions in Nicaragua / 269

3. Cost and Utilization Data for Nicaragua 271

Utilization / 271
Start-up / 272
Project Administration / 272
Program Production / 274
Transmission / 277
Reception / 278
Summary / 280

4. Analysis of Data 284

Implementation Alternatives / 284
Production for Upper Grade Levels / 296
Program Production Alternatives / 296
Transmission Alternatives / 297
Cost Implications of Alternatives / 299

References 299

*Jane Sachar*

*Chapter 10.* NICARAGUAN STANDARDIZATION OF THE STANFORD MENTAL ARITHMETIC TEST 301

1. The Stanford Mental Arithemetic Test (SMAT) 301

Development of the Nicaraguan Version of the SMAT / 302
The Norming Population / 303

2. Test Results 303

Means, Standard Deviations, and Medians / 304
Item Sequence / 313
Comparison of Item Performance Between Grades / 314
Relation Between Concepts / 317

3. Summary 319

References 320

APPENDIX A: Symbolic and Oral Forms of Arithmetic Exercises 321

APPENDIX B: Script for the Stanford Mental Arithmetic Test 322

APPENDIX C: Texto de la Prueba de Cálculo Mental de la Universidad de Stanford 328

APPENDIX D: Manual for Nicaraguan Mental Arithmetic Test 334

APPENDIX E: Performance of First- and Fifth-grade Nicaraguan and U.S. Students on the SMAT by Concept 349

INDEX 353

# FOREWORD

This report is the second in a series describing in detail the design, implementation, and evaluation of instructional radio used to teach primary school mathematics in rural Nicaragua. Since 1974, the Ministry of Public Education in Nicaragua and Stanford University have worked collaboratively on this Agency for International Development (AID) research and development project to demonstrate that rural schoolchildren can receive consistently high quality instruction in mathematics by radio.

Because of its inherent low cost and almost pervasive presence, radio has gained increasing attention in recent years as a means of delivering instruction within developing countries. The critical factor remains, however, the creative and effective development of the instructional programs actually broadcast on the radio. It is this component of the educational system that has received the most attention in the Radio Mathematics Project and for which the project staff feel justifiably proud. The first- and second-grade mathematics achievement scores indicate that the methods described in this report have significantly improved radio's performance as an instructional medium and have provided a solid contribution to improving the educational opportunity of rural school children.

We invite your critical review of this report and welcome your comments.

David Sprague

*Office of Education*
*Development Support Bureau*
*Agency for International Development*

10

# *Chapter 1*

## INTRODUCTION

BARBARA SEARLE, PATRICK SUPPES,
AND JOSÉ GONZÁLEZ

ALTHOUGH RADIO has been used in the classroom for more than 50 years, we are now learning new ways to increase radio's effectiveness as an instructional medium. Much of this experimentation is occurring in developing countries which face extraordinary problems in expanding the availability and improving the quality of primary education.

In 1973 the Development Services Bureau of the United States Agency for International Development (USAID) initiated an experimental project to test the feasibility of providing direct instruction in mathematics to primary-school children by radio. Most prior applications used radio lessons as an auxiliary to classroom teaching to provide enrichment or supplementary practice. USAID wanted to know if the medium could carry the full burden of instruction and if this form of instruction could improve the achievement levels of students at a cost acceptable to developing countries.

The Institute for Mathematical Studies in the Social Sciences (IMSSS) at Stanford University undertook the experimental program proposed by USAID and, in collaboration with the Ministry of Public Education of Nicaragua, established the Nicaragua Radio Mathematics Project. This volume reports the work of the project during 1976 and part of 1977. A previous book, ***The Radio Mathematics Project: Nicaragua 1974–1975***, by Searle, Friend, and Suppes (1976) describes the early work of the project and provides a detailed introduction to the methods of curriculum design and lesson production that have shaped project lessons. This volume continues the discussion of development work and presents evaluation results that document the effectiveness of project lessons.

The Nicaragua Radio Mathematics Project is responsible for all mathematics instruction received by children in participating classrooms. Daily lessons consist of two parts, a half-hour radio broadcast and a set of postbroadcast activities. These lessons are used by the children in the schools during their regular mathematics period. The teacher prepares the class for the radio broadcast, supervises the class during the broadcast lesson, and conducts supplementary activities for the remainder of the mathematics period. Pre- and postbroadcast activities are based on suggestions provided in a teacher's guide that is prepared and distributed by the project.

The content of the lessons is taken from the official syllabus of the Nicaraguan Ministry of Public Education. This is the same syllabus that guides the activities of teachers in traditional classrooms, and despite the pedagogical differences between the traditional style of instruction and the radio-based instruction, the content is essentially the same. There is, perhaps, a slight difference in that the radio programs emphasize arithmetic skills, mental calculations, and applications relevant to rural life in Nicaragua.

In chapter 2, Jamesine Friend, Vitalia Vrooman, Norma Guadamuz, Juan José Montenegro, and Barbara Searle describe the second-grade instructional program in detail with examples drawn from the radio lessons. They present evaluation results and relate test score gains to the content of the instructional program. The chapter builds on the extensive discussion of the first-grade program in Searle, Friend, and Suppes (1976) and examines the important ways in which the second-grade program differs from first grade one.

In chapter 3, Barbara Searle, Paul Matthews, Patrick Suppes, and Jamesine Friend describe the evaluation of the 1976 first-grade experimental program, focusing on achievement test results as the major measure of program effectiveness. Using stratified random sampling of classrooms, the evaluation documented the significant achievement gains of students using radio lessons as compared with those in traditional classrooms.

A program that aims to captivate its audience and to effectively teach a subject as difficult as mathematics should be developed according to a well-thought-out program design. The essence of the system is feedback. Although a detailed plan for the year is worked out before the lessons are written, this plan is altered dynamically throughout the year along lines indicated by performance data from participating children. These performance data come in part from weekly tests. Thus, the Nicaragua Radio Mathematics Project makes evaluation an integral part of the production process; lessons are designed with reference to test data from the lessons that have already been broadcast.

In chapter 4, Klaus Galda and Alicia de Quintanilla describe the weekly testing program that forms an essential component of the feedback system guiding the development of lessons. The tests, keyed to an explicitly defined curriculum plan, assess performance levels both before and after teaching important concepts and skills. The test results guide major decisions to modify the curriculum plan during the course of lesson development.

In addition to the content of the curriculum, the participating classroom teacher contributes to the effectiveness of the radio lessons. Although the teacher plays a minor role with respect to the teaching of content during the broadcast portion of the mathematics lesson, she (or he) can enhance the participation of the children and hence the effectiveness of the radio lessons. The attitudes and opinions of the classroom teachers toward the project are therefore important and worthy of investigation.

In chapter 5, Thomas Tilson and Barbara Searle report on an assessment of teacher attitudes toward radio instruction and other aspects of teaching. They document the favorable attitudes of teachers toward the use of radio lessons to teach mathematics. Their data show that teachers share the perception of classroom observers that students learning mathematics by radio are actively involved in the instructional process.

Project lessons are deliberately designed to stimulate the active participation of the learner in both broadcast and postbroadcast portions of the lessons; an average of five student responses per minute is elicited during the radio broadcast. These responses may be oral, written, or physical and vary with mathematical content and instructional strategy. Mathematical concepts, arithmetic skills, and problem-solving abilities are all taught in a direct, concrete style that children can understand and respond to. There is little lecturing, and technical vocabulary is held to a minimum. The programs incorporate entertainment as well as instructional segments. Songs, jokes, riddles, stories, and games are interspersed among the mathematical segments and are also based on the principle of active participation. Because of the pace of the broadcast, the high level of interest of the children, and the careful sequential development of mathematical concepts and skills, the broadcasts have been characterized as a cross between Sesame Street and programmed instruction.

In chapter 6, Thomas Tilson comments on these characteristics of the Nicaragua Radio Mathematics Project in a report of a detailed observation study of teachers in classrooms before and after the introduction of radio-based lessons. Tilson explores the levels and types of student-teacher interactions in the traditional classroom and compares them with interaction levels during the radio broadcasts and during the postbroadcast lessons taught by the teachers. Among the more important of Tilson's findings is the shift of teacher attention from high-ability students to low-ability students that accompanies the introduction of radio lessons in the classroom.

The capacity of an educational system to successfully and economically reach as many students as possible is directly related to the amount of wastage in the system, that is, the extent to which students repeat, drop out, and fail. As part of the experimental investigation of the use of radio for instruction, the Nicaragua Radio Mathematics Project collected information on student background characteristics and school, classroom, and teacher variables. These data have been used to examine the relationship between these variables and educational wastage and to assess the impact of radio instruction on educational wastage.

In chapter 7, Dean Jamison reports on a study of the relation of radio education to student repetition. Both repetition and dropout are discussed as serious inefficiencies in the primary school system of Nicaragua, and the implications of an increase in student achievement levels on the repetition rate are explored. Jamison extends the traditional production-function approach to analyzing output of an education system by using two outcome measures—posttest score and first-grade failure—to build a multiple output model. His analysis uses a set of recursive regression equations to model the flow of students from first to second grade and to assess the relative contributions of both endogenous and exogenous variables to rates of dropout and repetition.

In chapter 8, Barbara Searle, John Sheehan, José González, and Edward George chart patterns of flow of students in traditional Nicaraguan classrooms from first to second grade, examining the relative impact of age, school location (rural or urban), achievement levels, and previous repetition history on the likelihood of the students' being promoted, repeating the grade, or dropping out. The data indicate that, for the Nicaraguan students studied, dropping out is unrelated to levels of achievement, but that for given levels of achievement, students in rural areas have a poorer prognosis than those in urban areas. The detailed discussions convey the complexity of the issues surrounding the high repetition and dropout rates characteristic of Nicaragua and other developing countries.

The project method of developing lessons, which uses an extensive feedback system, requires a large staff for designing and administering tests and for observing scattered rural classes on a daily basis. Consequently, the curriculum development process is quite expensive. However, this is a one-time-only cost since the programs, once taped, can be used for several years. A substantial effort has been made to keep the eventual implementation costs low. No textbooks are required; each child has a small, inexpensive notebook, in addition to which seeds, bottle tops, and stones are used—all materials that can be easily found at no cost. The teacher is supplied with a teacher's guide, which, like the taped programs, is reusable. A radio receiver is also needed, but not one for each classroom, since the lessons for different grades are broadcast at different times and a single radio receiver serves several grades, being passed from one classroom to the next during a musical interlude that is provided specifically for this purpose. Thus the relatively high initial cost of curriculum development may be spread over a large student population, while low operating costs keep the yearly expenditure low.

In chapter 9, Stuart Wells and Steven Klees present the results of a cost study of the program that projects costs over a 25-year period under different assumptions about the rate of expansion of the project throughout the country. Their work also compares costs for alternative transmission mechanisms and examines the effect of the degree of electrification on reception costs.

A final major characteristic of the Nicaragua Radio Mathematics Project is the extent to which mental arithmetic exercises are used. In chapter 10, Jane Sachar describes the standardization of a new test of mental arithmetic skills to the Nicaraguan populations. Her work provides an opportunity, not available with school populations in the United States, to compare the effect of age (and hence maturation) with that of schooling on attainment of mental arithmetic skills. The test results show the far stronger effect of schooling as compared with maturation in the growth of such skills.

By sustained attention to educational, human, and economic considerations, the Nicaragua Radio Mathematics Project has attempted to bring to the children of Nicaragua an educational system that is of high quality and also well within the financial reach of the less developed countries. It is our belief that the program can be transferred to other countries and to other subject matters and thereby be applicable beyond the borders of Nicaragua.

The Nicaragua Radio Mathematics Project, the subject of this volume, was designed, written, and produced in Nicaragua under the direction of Project Director Jamesine E. Friend and Co-Director Vitalia R. Vrooman. Among the many staff members who contributed to the work are: David Cardoza Solis, Irmina Cuadra de Venegas, Norma Guadamuz de Velarde, Francisco Herrera Pérez, Inez del R. Larios, Julia Ledee, Gladys Gutiérrez López de Gámez, Juan José Montenegro Piñeda, Mirna Osorio Rúiz, Alicia de Quintanilla, Emigdio Quintero Casco, Luis Ramírez Albert, Thomas Tilson, Amelia

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Searle, B., Friend, J., & Suppes, P. *The radio mathematics project: Nicaragua, 1974-1975*. Stanford, Calif.: Stanford University, Institute for Mathematical Studies in the Social Sciences, 1976.

# Chapter 2

# THE SECOND-GRADE INSTRUCTIONAL PROGRAM

JAMESINE FRIEND, VITALIA VROOMAN,
NORMA GUADAMUZ, JUAN JOSÉ MONTENEGRO,
AND BARBARA SEARLE

THE INSTRUCTIONAL PROGRAM for Grade 2 consists of 175 lessons, each with a broadcast portion and postbroadcast activities that are described in a teacher's guide. The program was developed in 1976 and evaluated in 1977; during each of these two years approximately 1,400 second-grade students used the lessons. The design of the second-grade program followed closely the lesson structure and production methods developed for first grade in 1975, the project's first year of operation. For a detailed description of that work, see the first book of this series (Searle, Friend, & Suppes, 1976).

This chapter reports on the lesson development and evaluation for Grade 2. The first section describes briefly the method of lesson development and then discusses the components of the process, namely, instructional methods, curriculum design, and lesson structure. The second section presents evaluation results. A final section compares the programs for Grades 1 and 2. This last section is of particular interest because, although the instructional program for Grade 2 followed the style and organization of the program for Grade 1, it did not use student worksheets and in this respect marked a substantial change from the earlier work. The rationale for this change—reduction of implementation costs—is consistent with one of the paramount aims of the project: the design of an instructional program whose implementation costs could realistically be borne by the government of a developing country. The last section in this chapter discusses some of the implications of this change for lesson design; the cost implications are considered in chapter 9.

| Production of Lessons for Week: | Week: 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
|---|---|---|---|---|---|---|---|---|
| 44 | Prepare Lesson Outlines | Write Instructions and Teacher's Guides | Write Scripts | Produce Tapes | Broadcast and Observe | Test and Analyze Results | | |
| 45 | | Prepare Lesson Outlines | Write Instructions and Teacher's Guides | Write Scripts | Produce Tapes | Broadcast and Observe | Test and Analyze Results | |
| 46 | | | Prepare Lesson Outlines | Write Instructions and Teacher's Guides | Write Scripts | Produce Tapes | Broadcast and Observe | Test and Analyze Results |
| 47 | | | | Prepare Lesson Outlines | Write Instructions and Teacher's Guides | Write Scripts | Produce Tapes | Broadcast and Observe |
| 48 | | | | | Prepare Lesson Outlines | Write Instructions and Teacher's Guides | Write Scripts | Produce Tapes |
| 49 | | | | | | Prepare Lesson Outlines | Write Instructions and Teacher's Guides | Write Scripts |

FIGURE 1. A portion of the production schedule.

## 1. DEVELOPMENT OF THE SECOND-GRADE INSTRUCTIONAL PROGRAM

Information about student performance plays a central role in the process of lesson development, and during the developmental year the selection of radio classes, the production schedule, and the gathering of data are all organized to facilitate the use of such information. In 1976, 20 second-grade classes in the department of Masaya served as test classes. Twelve of these were given weekly tests and, of these, five were observed regularly. All classes were visited periodically to obtain information about lesson implementation. (An additional 20 classes, in the departments of Masaya, Granada, and Carazo, used radio lessons; these were taught by teachers who had worked with the project before and had requested permission to continue using radio lessons.)

The 20 test classes were not selected randomly; rather, we followed the 1975 procedure, choosing classrooms that were easily reached from the project office, yet represented the wide range of situations normally found in surrounding departments. There were, for example, classes taught by teachers rated as good and as poor by the local school inspector, there were classrooms with more than one grade in the same room, there were rural schools and urban schools, and so on. Three of the classes had mostly students who had used the radio program in first grade in 1975.

Feedback was obtained from weekly tests and daily classroom observations. Twenty-six tests were administered during the 34-week school year. (Weekly tests are described in chap. 4.) The tests used a matrix sampling design that allowed collection of data on as many as 45 items a week. Performance levels were assessed before and after topics were taught, and this information played a crucial role in determining the content of the lessons. Each lesson was observed in at least two different classrooms by project staff members trained (by the project) as classroom observers. The reported 425 observations provided information about such aspects of lesson design as timing, suitability of language and speed of speech, clarity of instructions, pacing, attitudes, and behavior.

The lesson-production schedule was geared to the data-collection process. The time between recording a lesson and broadcasting it was kept short to maximize the sensitivity of the development process to observation and test results. The production cycle is shown in Figure 1. The production of lessons for Week 44, for example, begins in Week 40 with the preparation of outlines. During the next week, instructional dialogue for the five lessons is written by script writers and reviewed by the curriculum developer. In Week 42 the script for each lesson is prepared, using the instructional material written the week before and incorporating entertainment segments. The lessons are taped in Week 43 and broadcast in Week 44. Test and observation data are analyzed during Week 45.

Looking at the column headed "Week 45" we see that the data collected on the lessons broadcast in Week 44 can be used to change the outlines for the lessons for Week 49, can affect the instructional dialogue written for Week 48, can influence the scripts for Week 47, and can be used to make last-minute changes in the lessons for Week 46. Thus, the turnaround time for making changes ranges from two to five weeks, depending on the type of change required.

### *Instructional Methods*

Project lessons are built around a fast-paced dialogue between students and radio characters. During the instructional portions (segments) of the lesson, four major types of responses are elicited from the children: immediate oral, delayed oral, written, and physical responses.

The immediate oral response is used in two different circumstances. When a concept or skill is first being taught, a response by a few children helps others know what answer is expected. Later, when exercises are being practiced, especially those that should be memorized, all (or almost all) of the children are able to participate in a fast-paced drill. In between these situations, the delayed oral response allows all the children to participate in working exercises and responding aloud.

In the delayed oral response, the children are asked first to "think" of the answer, then to give it aloud. For example,

> "Think of twenty-six minus two."
> *pause—6 seconds*
> "How much is it?"

The children are taught not to speak aloud until they are asked to respond in the second part, in order to give everyone a chance to think of the answer.

The dialogue that guides children through written exercises is much more complicated than the interchange presented above. As an illustration we show here the interchange for working through a vertical subtraction exercise (translated from Lesson 101). The dialogue is between two main radio characters, Lita and Ramón, and the "chorus" (child actors' voices), which plays the role of the children in the classroom.

1. **RAMÓN:** Let's look at the last exercise in the row. It's 82 minus 45. (Ramón is referring to exercises written on the chalkboard and in the children's notebooks.)
2. **LITA:** First, let's see if we have to borrow. Look at the 2. Tell me, can we take 5 from 2?
3. **CHORUS:** No.
4. **RAMÓN:** No, we can't. So—do we have to borrow?
5. **CHORUS:** Yes.
6. **LITA:** Yes, we must borrow. We'll borrow 1 from the 8.
7. **RAMÓN:** 8 minus 1, 7. Cross out the 8. *pause 2 sec.* Tell me, where are you going to write the 7?
8. **CHORUS:** Above the 8.
9. **LITA:** Above the 8. Write it. *pause 4 sec.*
10. **RAMÓN:** Now we have to write the 1 that we borrowed. Tell me, where are we going to write it?
11. **CHORUS:** In front of the 2.
12. **LITA:** In front of the 2. Write it, small. *pause 3 sec.*
13. **RAMÓN:** Now, instead of 2 what do we have?
14. **CHORUS:** 12.
15. **LITA:** 12. Now we're finished borrowing.
16. **RAMÓN:** Tell me, can we subtract 5 from 12?
17. **CHORUS:** Yes.
18. **LITA:** Yes, of course. We can subtract 5 from 12. So we're going to subtract. Think of 12 minus 5. *pause 5 sec.*
19. **RAMÓN:** How much is it?
20. **CHORUS:** 7.
21. **LITA:** 7. Find the space under the 5. Write the 7 there. *pause 4 sec.*
22. **RAMÓN:** Now move to the next column. Here we used to have 8 minus 4. What do we have now?
23. **CHORUS:** 7 minus 4.
24. **RAMÓN:** And 7 minus 4, how much is it?
25. **CHORUS:** 3.
26. **LITA:** 3. Write it under the 4. *pause 4 sec.*
27. **RAMÓN:** Look at your answer. Read it.
28. **CHORUS:** 37.
29. **LITA:** 37. Good.

This dialogue takes 2 minutes and 10 seconds of lesson time. It asks for nine immediate oral responses, one delayed oral response, and five written responses (about seven responses per minute). The two parts of the delayed oral response are found in Lines 18 and 19.

Only a few of the immediate oral responses are numbers; most relate to steps in the process of working the exercise. The language used by the chorus in Lines 8 and 11 is that generally used by students in the traditional classrooms. Usually, the children in the classroom respond with the same words as the chorus, drowning out the recorded voices. However, if the children cannot respond, the chorus serves as a prompt. The function of giving the correct answer is handled explicitly by an adult character after the chorus and the children have responded, as in Lines 9 and 12.

The instruction in Line 21 illustrates a rule of thumb for writing instructions: When the children are not thoroughly familiar with a process, always give a series of instructions in the order the children are expected to carry them out. In this case, the child must first find the place to write the numeral (under the 5) and then write it. Because by the time this lesson is presented the children have done many subtraction exercises and are familiar with column format, this rule can be relaxed, as it is in Line 26.

This dialogue illustrates the attention given in the instructional process to the format of the exercises. In the traditional classroom, the children are expected to learn about format from observation. Thus, the position of the digits of the answer with respect to the minuend and subtrahend and the mechanics of borrowing are presumably demonstrated by the teacher. The radio teacher cannot demonstrate these and must rely entirely on verbal description. This has proved to be one of the most difficult aspects of creating successful instructional dialogue, but the difficulty can be overcome by a careful analysis of the concept or skill being taught. In fact, this circumstance has proved to be a strength of the instructional system, because we must write the instruction so that the children give their own demonstrations. We think that this process enhances learning.

### *The Curriculum*

The curriculum for Grade 2 was based on the curriculum specifications of the Ministry of Public Education. The Ministry guide identifies eight sequential units: sets, systems of numeration, addition and subtraction, multiplication and division, common fractions, money, measurement, and geometry. In designing the curriculum for the radio lessons, we deviated in two respects from the official guide: We did not teach formal set notation (instead, we taught set concepts and related them immediately to work on numeration and the four operations), and we changed substantially the sequencing of the material.

The Ministry curriculum guide presents together all the subtopics of a topic and suggests to the teachers a time span (e.g., three weeks) in which to cover each topic, clearly implying that a topic, such as addition, be taught over one continuous period. Furthermore, the guide makes no provision for review, so that a teacher following the guide would touch on each topic only once. The project staff takes the view that all topics should be presented throughout the year, and in the curriculum for radio lessons there is an extensive interweaving of teaching, practice, and review. However, underlying the daily lessons is a curriculum structure much like that of the Ministry guide.

In the remainder of this section we first discuss the details of the project curriculum, which is organized in three levels: *topics*, which correspond to the topics described in the Ministry curriculum; *strands*, which correspond to the subtopics of the Ministry guide; and *exercise classes*, which are a finer division yet, specifying a homogeneous set of exercises that are taught and reviewed together. We then describe how this basic curriculum structure is used to design weekly lesson plans and then daily lessons.

**The structure of the curriculum.** Table 1 presents the 10 topics that constitute the second-grade mathematics curriculum, together with their further subdivision into a total of 31 strands, or subtopics.[1] As noted above, each strand is further divided into classes of exercises, each of which is explicitly defined in terms of the characteristics of the exercise and the type of response asked for. Table 2 describes some typical exercise classes. For example, Oral Addition class 1 (AO1) consists of exercises that are sums of single digits, with the sum no more than 10; the exercises are presented orally and the children are expected to respond orally. The table shows for each sample class a definition and an example. In the examples, quotation marks indicate oral presentation. A full list of the exercise classes comprised by the second-grade curriculum is presented in Appendix A.

The list of 31 strands in Table 1 describes the curriculum that resulted from the development work in 1976. It differs slightly from the list prepared at the beginning of that year to guide the curriculum-development work. The initial plan included the 33 strands shown in Table 3 and 183 exercise classes. During the year, one strand (number sequences—NS) was added to the plan and two (word problems in numeration and measurement—PN and PME) were deleted. Other changes brought the number of exercise classes to 270. These changes were made on the basis of information obtained from weekly tests and classroom observations as mentioned above and discussed further below.

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[1] The curriculum designed by the project staff specifies the material to be taught in *both* parts of the mathematics lessons—the radio portion and the postbroadcast portion. However, for simplicity, in the subsequent discussion we will refer to it as the *radio curriculum*.

TABLE 1

Topics and Strands Comprising the Second-grade Curriculum

| Strand identifier | Strand description |
|---|---|
| | Numeration |
| NC | Counting |
| NE | Reading and writing whole numbers |
| NM | Comparisons—more or less |
| NS | Number sequences |
| OR | Ordinal numbers |
| FR | Reading and writing fractions |
| | Addition |
| AO | Addition exercises presented orally |
| AV | Addition exercises in vertical format |
| AH | Addition exercises in horizontal format |
| | Subtraction |
| SO | Subtraction exercises presented orally |
| SV | Subtraction exercises in vertical format |
| SH | Subtraction exercises in horizontal format |
| | Addition and subtraction combined |
| CO | Oral exercises calling for both addition and subtraction |
| CH | Combined exercises in horizontal format |
| | Multiplication |
| MO | Multiplication exercises presented orally |
| MV | Multiplication exercises in vertical format |
| MH | Multiplication exercises in horizontal format |
| | Division |
| DO | Division exercises presented orally |
| DV | Division exercises using long division format |
| | Operations with fractions |
| AF | Addition of fractions |
| SF | Subtraction of fractions |

(TABLE 1, cont.)

| Strand identifier | Strand description |
|---|---|
| | **Word problems** |
| PA | Word problems using addition, presented orally |
| PS | Word problems using subtraction, presented orally |
| PM | Word problems using multiplication, presented orally |
| PD | Word problems using division, presented orally |
| | **Measurement** |
| MB | Money |
| MT | Time |
| ML | Length |
| MP | Weight |
| MC | Volume |
| | **Geometry** |
| GE | Geometry |

**Development of the curriculum master plan.** The curriculum as described thus far is merely a list of topics. We must next indicate how the topics are related to each other and how their presentation is distributed throughout the 34 weeks of the school year. We illustrate these two points using the horizontal subtraction (SH) strand, chosen because it is one of the more simple strands. (The full curriculum structure exemplified here by horizontal subtraction will be published separately.)

Table 4 shows the eight exercise classes in the SH strand and gives a brief description of each class. All contain subtraction exercises written in horizontal format and require written answers; they differ in the size and relationships of the minuend and subtrahend. The table gives three other pieces of information about each class: the lesson number in which it is first used, the exercise classes (from SH and other strands) that are prerequisites for the class, and the numbers of the lessons in which the prerequisite classes are taught.

TABLE 2

Sample Exercise-class Definitions from Second-grade Curriculum

| Class identifier | Class description[a] | Example |
|---|---|---|
| AO1 | a + b: sum less than or equal to 10 (oral) | "How much is 2 plus 7?" |
| AH4 | a0 + b0: sum less than or equal to 90 (horizontal) | 30 + 50 = ___ |
| AV29 | ab + cd + ef: carry 2 in column 1 (vertical) | 29<br>45<br>+18 |
| SO1 | a−b: (oral) | "How much is 6 minus 3?" |
| SH8 | ab−c: no borrow (horizontal) | 40−3 = ___ |
| SV4 | ab−c: no borrow (vertical) | 68<br>− 5 |
| MO1 | a×b: product less than 10 (oral) | "How much is 2 times 3?" |
| MH1 | a×b: product less than 10, factors greater than 1 (horizontal) | 4×2 = ___ |
| MV1 | a×b: same as above (vertical) | 3<br>×2 |
| DO1 | a ÷ b: b = 2, 3, 4, a less than 10, and a multiple of b (oral) | "How much is 9 divided by 3?" |
| DO2 | ab ÷ c: c = 2, 3, 4, or 5, ab is a multiple of c, and ab ÷ c ≤ 5 (oral) | "How much is 12 divided by 4?" |
| NM3 | Comparison: greater than, to 99, ab vs. ac | "Which is greater, 53 or 58?" |
| NE2 | Writing numerals, abc | "Write 278" |

[a] Lowercase letters are used to represent single digits. These class descriptions are given using more precise mathematical notation in project documentation; less formal descriptions are used here for simplicity of presentation.

TABLE 3

Distribution of Exercise Classes Among Strands: Planned and Final Radio Curriculum

| Strand | Number of classes | | Strand | Number of classes | |
|---|---|---|---|---|---|
| | Planned | Final | | Planned | Final |
| NC | 9 | 11 | DO | 2 | 2 |
| NE | 10 | 6 | DV | 6 | 6 |
| NM | 6 | 6 | DH | 2 | |
| NS | | 1 | | | |
| OR | 4 | 5 | AF | 2 | 3 |
| FR | 6 | 11 | SF | 1 | 1 |
| AO | 10 | 13 | PA | 1 | 16 |
| AV | 29 | 35 | PS | 1 | 13 |
| AH | 10 | 12 | PM | 1 | 11 |
| | | | PD | 1 | 4 |
| SO | 8 | 9 | PN[a] | 1 | |
| SV | 39 | 27 | PME[b] | 1 | |
| SH | 8 | 8 | | | |
| | | | MB | 1 | 3 |
| CO | 1 | 3 | MT | 1 | 8 |
| CH | 1 | 1 | ML | 1 | 11 |
| | | | MP | 1 | 7 |
| MO | 3 | 5 | MC | 1 | 6 |
| MV | 11 | 20 | | | |
| MH | 3 | 5 | GE | 1 | 1 |
| | | | TOTAL | 183 | 270 |

[a] Word problems in numeration.

[b] Word problems in measurement.

The table is the end product of a process that starts with determining the *order* in which exercise classes within each strand will be taught. As shown in Table 4, the order in which the classes are defined is not necessarily that in which they will be taught. For the SH strand the teaching order is: SH1, SH2, SH8, SH4, SH3, SH7, SH5, SH6. (Note that even if the classes are written in the expected teaching order at the outset, the ordering may be changed later as a result of information about student performance.) Classes SH3 through SH7 all involve zeros, either in the exercise statement or in the answer. The curriculum developer has chosen (on the basis of test data as well as previous experience) to teach the remaining classes first

TABLE 4

Teaching Order and Prerequisites for Horizontal Subtraction Strand

| Identifier | Class description | First lesson used | Prerequisite classes | First lesson for prerequisites |
|---|---|---|---|---|
| SH1 | $M-b, M < 11$ | 17 | SO1 | 1 |
| SH2 | $1a-b, b > a$ | 23 | SO2 | 11 |
| | | | AH2 | 21 |
| SH3 | $ab-b = a0$ | 46 | SO3 | 42 |
| | | | SH4 | 42 |
| SH4 | $a0-b0 = c0$ | 42 | SO4 | 36 |
| | | | SH1 | 17 |
| SH5 | $a00-b00 = c00$ | 71 | SO5 | 66 |
| | | | SH4 | 42 |
| SH6 | $abc-bc = a00$ | 86 | SO6 | 77 |
| | | | SH3 | 46 |
| SH7 | $ab-a0 = b$ | 51 | SO7 | 46 |
| | | | SH3 | 46 |
| | | | SH4 | 42 |
| SH8 | $ab-c, c \leq b$ | 27 | SO8 | 21 |
| | | | SH1 | 17 |

(SH1, SH2, SH8) and then deal with zeros, starting with differences involving multiples of 10 (SH4).

Once an initial order of classes has been determined, the next step is to identify the exercise classes that are prerequisite to each SH class. All the classes have as a prerequisite the class from the Oral Subtraction (SO) strand that has the same definition, because the students are expected to do the exercises presented in horizontal format "in their heads." That is, these exercises are designed to call upon mental arithmetic skills, even though both the presentation and the response are written. Many of the SH classes have other SH classes as prerequisites. One class, SH2, has a prerequisite from another operation: AH2 contains the addition exercises ($a + b$, sum greater than 10) that correspond to the subtraction exercises in SH2.

Once the two-step process of determining order and prerequisites has been completed for all strands, the curriculum developer can lay out the master curriculum plan for the year, specifying the week during the school year that each exercise class is first taught. The plan controls only the introduction of each type of exercise, not subsequent practice and review.

The allocation of exercise classes to particular weeks is guided by a series of constraints.

1. Classes within a strand must be taught in the specified order.
2. The teaching week for a class must be later than the teaching weeks for all prerequisite classes.
3. After the first few weeks, no more than two major topics should be taught in any given week. (This is an empirically derived "rule of thumb.")
4. The total number of different topics taught in a week should be about six to eight (another empirical rule of thumb).

A fifth constraint concerns the effect of certain types of prerequisite classes, called key prerequisites, on the structure of the master plan, and its explanation requires an extended diversion, which follows.

**Key prerequisites.** The curriculum master plan as we have described it thus far assumes that teaching will always be successful—that when a concept or skill (represented by an exercise class) is taught, the children will learn it. That does not always happen. A unique feature of the project's method of lesson development is the flexible structure of the master plan, which allows curriculum developers to respond to feedback about student performance. The mechanism works as follows. A small number of exercise classes (30 of the 270 comprised by the curriculum) are identified as topics on which further development depends; they are labeled ***key prerequisites***.[3] Here are some examples.

MO1 (oral multiplication, single digits) is a key prerequisite for MV4 (multiplication of a two-digit number by a one-digit number).

AV9 (carrying in a two-column, two-addend addition exercise) is a key prerequisite for AV10, AV11, AV23, and AV27 (exercises with more than two columns or more than two addends, with carrying).

FR4 (reading and writing simple fractions with denominators of 2, 3, 4, and 5) is a key prerequisite for FR5 (comparing simple fractions) and for AF1 (adding simple fractions).

SV18 (borrowing in a two-column subtraction exercise) is a key prerequisite for SV19 and SV20 (three-column subtraction exercises with borrowing).

In each case, the curriculum designers have decided that instruction in the subsequent topic cannot be successful until the earlier topic has been mastered. This decision is incorporated into the master plan by scheduling the teaching of all subsequent exercise classes at least five weeks later than the teaching of the key prerequisite class, to allow the collection and analysis of student performance data. These data will indicate either that the teaching of the subsequent class can take place as scheduled or that it must be delayed until the key prerequisite class has been retaught to raise student performance to an acceptable level. We decided on five weeks as the time lag between teaching the key prerequisite and its subsequent classes because, on our tightest production schedule, this is the time it takes to carry out all the intervening steps as described above.

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[3] The key prerequisite classes are distributed among topics in the second-grade curriculum as follows: 6 in numeration, 11 in addition, 8 in subtraction, 4 in multiplication, and 1 in word problems.

The master plan lists the exercise classes that will be taught each week. However, it does not specify how many times during the week the designated exercises will appear in lessons, nor does it specify which other topics will be reviewed. These decisions are incorporated into a weekly plan.[3] The usual practice in the second-grade curriculum was to teach a new topic in five consecutive lessons, then review it for the first time sometime during the next five lessons. Decisions about subsequent review were made with information from classroom observations and weekly tests.

**Lesson segments.** As we saw in Table 2, an exercise class specifies a type of exercise. Exercises from a particular class may occur in as few as one or as many as 20 lessons; each set of exercises occurring in a lesson is called a *lesson segment.* Thus, the mathematical content of a lesson consists of a series of discrete lesson segments, each of which is defined from one (or occasionally two) exercise classes. We turn now to a more detailed look at the structure of a lesson.

### *The Lesson Structure*

A lesson is constructed from instructional and entertainment segments. These are written separately and incorporated into a single script only at the last stage of lesson development.

**Instructional segments.** The curriculum master plan is translated into directions for producing lessons through the lesson outline, which defines explicitly the mathematics content of the lesson. A typical outline (from Lesson 171) is shown in Table 5. The lesson has 12 instructional segments—8 during the radio lesson, a transition segment in which exercises are dictated by the radio and the children complete them after the broadcast, and 3 segments in the postbroadcast portion. The outline identifies and describes the exercise class for each segment and lists the actual exercises in the order in which they are to be presented to students. It also indicates whether responses are oral or written and which exercises are to be copied from the chalkboard.

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[3] Lessons were planned in groups of five, regardless of the actual school calendar. Thus, because of intervening holidays, lessons for Week 25 may not actually be broadcast Monday through Friday of the 25th week after the start of school.

TABLE 5

Outline for Lesson 171, Grade 2

| Segment number | Pr[a] | Exercise classes | Segment description |
|---|---|---|---|
| 1 | R | MT8 | Measuring time, hour, passing of time. (Oral.) [hour, half hour] |
| 2 | R | AO5 | Oral addition, $a0 + b$. [40 + 8; 60 + 3; 90 + 2; 70 + 5] |
| 3 | R | AF1 | Addition of fractions, $a/b + c/b$, $a + c \leq b$, $b = 2, 3, 4, 5, 10$. (Copied from chalkboard.) [1/3 + 1/3; 2/5 + 1/5; 4/10 + 1/10; 1/4 + 2/4] |
| 4 | R | SO2 | Oral subtraction, $1a-b$, $b > a$. (Delayed oral response.) [12−4; 17−8; 11−5; 15−8] |
| 5 | R | AV9 | Vertical addition, $ab + cd$, with carry, without passing. (Copied from chalkboard.) |
|  |  | SV18 | Vertical subtraction, $ab-cd = ef$, with borrow. [45 + 27; 52−17; 76 + 19; 82−45] |
| 6 | R | NM5 | Greater than, to 999, 3 alternatives. (Oral, exercises on chalkboard.) [258 vs. 582 vs. 825; 706 vs. 670 vs. 607; 341 vs. 413 vs. 134] |
| 7 | R | DO4 | Oral division, $ab \div c \leq 5$, $c = 3, 4, 5$, remainder, with drawings. (Written.) [13÷5; 15÷5; 10÷3] |
| 8 | R | PS3 | Word problems using subtraction, $ab-b$. (Written.) [42−2; 56−6] |
| 9 | T | MV21 | Vertical multiplication, $abc \times d$, with carry, from dictation. [168×4; 169×3; 406×2; 153×5] |
| 10 | P | SV34 | Vertical subtraction, $abc-def = ghi$, borrow in 2 columns. (Copied from chalkboard.) [540−286; 945−757; 850−279; 562−173] |
| 11 | P | DV4 | Vertical division, $ab \div c$, $c = 2, 3, 4, 5$, $a$ divisible by $c$, $b > c$. |
|  |  | DV5 | Vertical division, $abc \div d$, $d = 2, 3, 4, 5$, $a$ divisible by $d$, $b$ divisible by $d$. (Copied from chalkboard.) [85÷2; 847÷4; 68÷3; 465÷2] |
| 12 | P | NE5 | Writing numerals from dictation, to 9,999. [5091; 3871; 2302; 6800; 9001; 4101] |

[a] Mode of presentation: R = radio; T = presented by radio for use after the broadcast; P = postbroadcast, contained in teacher's guide.

TABLE 6

Distribution of Segments Among Mathematical Topics in the Second-grade Curriculum

| Topic | Number of segments | | | |
|---|---|---|---|---|
| | Recorded | Transition | Postbroadcast | Total |
| Numeration | 243 | 0 | 117 | 360 |
| Addition | 339 | 37 | 192 | 568 |
| Subtraction | 356 | 24 | 129 | 509 |
| Addition and subtraction | 12 | 1 | 2 | 15 |
| Multiplication | 232 | 16 | 59 | 307 |
| Division | 80 | 7 | 18 | 105 |
| Operations with fractions | 43 | 0 | 0 | 43 |
| Word problems | 111 | 0 | 6 | 117 |
| Measurement | 33 | 0 | 84 | 117 |
| Geometry | 0 | 0 | 1 | 1 |
| TOTAL | 1,449 | 85 | 608 | 2,142 |
| Percentage of all segments | 68% | 4% | 28% | |

The instructional segments in the lesson come from 12 different exercise classes. This level of diversity is typical of project lessons. Table 6 shows the distribution of segments among topics in the second-grade curriculum. About two-thirds of the segments are in the recorded portion of the lesson. For the remainder, the children work the exercises in the postbroadcast period.

Table 7 gives information about the exercises in the curriculum. The 2,142 lesson segments contained 8,319 exercises, divided equally between exercises used for teaching and those used for review. (To help the reader put these numbers into perspective, we note that three U.S. second-grade textbooks surveyed in 1969 had approximately 2,650 exercises each [M. Morningstar, personal communication, 1969].)

Table 8 examines in detail the types of responses students are asked to make during typical lessons. The table shows the numbers of physical, delayed oral, immediate oral, and written responses asked for and presents the mean number of responses per exercise. This last figure ranges from 2.1 to 7.0 responses. These lessons, on the average, have 30 exercises and ask for 110 responses, about 27% of which are written. The average number of responses per exercise is 3.7.

### TABLE 7

### Distribution of Exercises Among Mathematical Topics in the Second-grade Curriculum

| Topic | Number of exercises | | | Proportion of exercises |
|---|---|---|---|---|
| | Teaching | Review | Total | |
| Numeration | 945 | 734 | 1,679 | .20 |
| Addition | 1,001 | 1,017 | 2,018 | .24 |
| Subtraction | 698 | 1,082 | 1,780 | .21 |
| Addition and subtraction | 45 | 31 | 76 | .01 |
| Multiplication | 748 | 878 | 1,626 | .20 |
| Division | 121 | 255 | 376 | .05 |
| Operations with fractions | 49 | 82 | 131 | .02 |
| Word problems | 311 | 54 | 365 | .04 |
| Measurement | 238 | 25 | 263 | .03 |
| Geometry | 5 | 0 | 5 | .00 |
| TOTAL | 4,161 | 4,158 | 8,319 | |

### TABLE 8

### Frequency of Response Types for Mathematical Exercises in Selected Second-grade Lessons

| Lesson number | Number of exercises | Number of responses | | | | | Responses per exercise |
|---|---|---|---|---|---|---|---|
| | | Physical | Delayed oral | Immediate oral | Written | Total | |
| 21 | 32 | 11 | 12 | 64 | 19 | 106 | 3.3 |
| 32 | 33 | 0 | 9 | 59 | 22 | 90 | 2.7 |
| 43 | 34 | 0 | 10 | 44 | 17 | 71 | 2.1 |
| 54 | 37 | 0 | 32 | 53 | 23 | 108 | 2.9 |
| 65 | 36 | 0 | 16 | 51 | 27 | 94 | 2.6 |
| 101 | 32 | 0 | 4 | 116 | 34 | 154 | 4.8 |
| 112 | 30 | 0 | 10 | 96 | 51 | 157 | 5.2 |
| 123 | 25 | 0 | 14 | 70 | 37 | 121 | 4.8 |
| 134 | 16 | 0 | 16 | 60 | 36 | 112 | 7.0 |
| 145 | 24 | 0 | 7 | 50 | 32 | 89 | 3.7 |
| Average | 29.9 | 1.1 | 13.0 | 66.3 | 29.8 | 110.2 | 3.69 |

These figures give a clear picture of the highly interactive character of the instructional method used in the radio lessons. They also show the heavy emphasis on oral work: About 72% of the responses made by the children are oral.

**Entertainment segments.** The entertainment segments (which occur only in the recorded portion of the lesson) are quite different from the instructional segments and effectively change the pace of the lesson. The distribution of types of entertainment segments in the second-grade lessons is shown in Table 9. The 175 lessons contain 931 recorded entertainment segments, an average of 5.32 per lesson. The frequency of entertainment segments was greater during the first half of the year and tapered off during the later lessons—the mean occurrence for the first 60 lessons was 6.0, compared with 4.5 for the last 60 lessons.

More than 60% of the entertainment segments were songs and another 18% involved physical games, which were used in almost every lesson. Riddles also occurred frequently—in 135 lessons. The remaining types of entertainment—jokes, recitations, bombas (traditional short poems), and tongue twisters—appeared infrequently.

The use of entertainment can be illustrated by Lesson 171. (The script and teacher's guide for Lesson 171 can be found in Appen-

TABLE 9

Types of Entertainment Segments in Second-grade Lessons

| Lessons | Number of occurrences | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Song | Game | Riddle | Joke | Recitation | Bomba | Tongue twister | Total |
| 1–15 | 34 | 15 | 11 | 5 | 2 | 5 | 1 | 73 |
| 16–30 | 54 | 15 | 14 | 1 | 5 | 2 | 0 | 91 |
| 31–45 | 65 | 15 | 15 | 0 | 2 | 3 | 0 | 100 |
| 46–60 | 67 | 14 | 11 | 0 | 1 | 0 | 0 | 93 |
| 61–75 | 46 | 13 | 9 | 0 | 0 | 0 | 0 | 68 |
| 76–90 | 54 | 15 | 14 | 3 | 2 | 1 | 3 | 92 |
| 91–105 | 61 | 14 | 10 | 0 | 0 | 1 | 2 | 88 |
| 106–120 | 34 | 12 | 9 | 2 | 0 | 0 | 2 | 59 |
| 121–135 | 37 | 13 | 13 | 0 | 1 | 0 | 2 | 66 |
| 136–150 | 44 | 15 | 11 | 1 | 2 | 3 | 2 | 78 |
| 151–165 | 39 | 15 | 11 | 0 | 2 | 1 | 2 | 70 |
| 166–175 | 30 | 10 | 7 | 3 | 0 | 3 | 0 | 53 |
| TOTAL | 565 | 166 | 135 | 15 | 17 | 19 | 14 | 931 |

dix B.[4] ) The lesson has seven entertainment segments—four songs, a game, a riddle, and a joke. Songs in general are of two types; traditional or folk songs and songs written specifically for project lessons, usually about mathematics. For example, one song in Lesson 171 teaches about time. The words of the first stanza (freely translated) are:

The ticktock of the clock does remind us
The hours are something we must know.
An hour is sixty whole minutes.
Sixty minutes is an hour entire.

Lesson 171 also contains a joke:

**VOICE:** The mother and child are talking.

**CHILD:** Mommy, Mommy. Give me a córdoba.

**MOTHER:** Another? But . . . what have you done with the one I gave you this morning?

**CHILD:** I gave it to an old man.

**MOTHER:** I like it, son, that you are charitable. Then take another córdoba. . . . But let's see, tell me, you won't give this cordoba to the old man, will you?

**CHILD:** Of course, Mommy, because he is the one who sells candies.

Although there were almost a thousand entertainment segments in the 175 lessons, they were not all unique. As shown in Table 10, the entertainment component consisted of 181 segments repeated, on the average, about five times. The repetition rate for songs and games was high: 66 different recorded segments provided 731 occurrences, almost 80% of all the entertainment in the lessons. The entertainment segments were repeated so that the students would learn the words and music and participate more fully. Specifically, jokes and riddles were repeated so that students who for some reason were not listening or did not understand what was said would have the opportunity to hear the joke or riddle again or, better still, would memorize the idea and later repeat it to other children. Although the entertainment segments used the same songs and games, in most cases the setting and surrounding dialogue were changed so that the children did not hear exactly the same thing every time.

The pattern of usage for different types of entertainment was determined by the children's responses to these types, as reported by classroom observers. Each type of entertainment was included in the

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[4] Although Lesson 171 won the Japan Prize in 1977, it is, in fact, a typical lesson.

TABLE 10

Entertainment Segments in Second-grade Lessons

| Segment | Total number of occurrences | Number of distinct segments | Mean usage |
|---|---|---|---|
| Songs | 565 | 44 | 12.8 |
| Games | 166 | 22 | 7.5 |
| Riddles | 135 | 73 | 1.8 |
| Jokes | 15 | 10 | 1.5 |
| Recitations | 17 | 12 | 1.4 |
| Bombas | 19 | 13 | 1.5 |
| Tongue twisters | 14 | 7 | 2.0 |
| TOTAL | 931 | 181 | 5.1 |

second-grade lessons, both early and late in the year. The observations of level of interest in each type of entertainment paralleled those found for the first grade; songs, games, and riddles were the most engaging activities, with the children less interested in the other activities. The list of entertainment activities does not include stories, which traditionally fall into this category, because their use had been discontinued before we embarked on producing second-grade lessons.[5]

**Lesson construction.** Each lesson was put together from the appropriate instructional segments prepared by the script writers and from entertainment segments prepared by an individual solely responsible for choosing and arranging these with the mathematical material at the time the radio script is written. In our early work we attempted to provide a unifying theme or story for a lesson on the assumption that such lessons would prove more appealing to the children. Since it is difficult to invent such themes and stories, we instead tried simply concatenating segments and found that such lessons were just as successful as (and sometimes more so than) those with unifying themes. We therefore adopted our present practice of constructing lessons from unrelated segments. Several principles guide their placement, however. In the second-grade lessons, segments requiring only oral responses usually precede those requiring a notebook. Since the second graders have some difficulty getting

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[5] See Searle et al. (1976) for further discussion of first-grade children's responses to stories. The project experimented with stories again at the fourth-grade level and found these students more interested and better able to listen to stories. However, the level of interest in the mathematics segments remained high and the stories were not used to generate interest in mathematics but as an alternate type of entertainment.

notebooks and pencils ready, we ask them to do it only once. Entertainment segments are usually placed after each two or three instructional segments. Often the lesson opens with a song; a transition segment, if it is present, is the last activity in the recorded portion of the lesson.

## 2. EVALUATION OF THE SECOND-GRADE PROGRAM

### *Summative Evaluation Design*

A preliminary summative evaluation was carried out on the second-grade curriculum in 1976 with randomly selected control classes but volunteer experimental classes. The results from this study, reported in Searle, Friend, Suppes, and Tilson (1977), were not conclusive because of the nonrandom selection of the radio classes and because of an error made in distributing the posttest forms to the classrooms.

The formal summative evaluation was conducted in 1977. The experimental group consisted of two sets of classes, all of which were selected at random: 18 classes whose students had no previous experience with the radio lessons—the "nonexperienced students," and 24 classes whose students were part of the first-grade experimental group the preceding year—the "experienced students." Thus, the design lets us assess the cumulative effect of radio lessons.

Twenty-four control classes were taken at random. The experimental and control classes were each distributed equally among the departments of Masaya, Granada, and Carazo and between urban and rural schools.

The nonexperienced experimental group was pretested and posttested in 1977. The experienced experimental group was posttested in 1977; they were not pretested because of other demands on the project resources.[6] The control group was also posttested but not pretested in 1977.[7] Because the experimental and control classes were all taken at random, it is appropriate to make a posttest-only comparison; we present these results in the next section.

### *Evaluation Results*

As can be seen in Table 11, which presents the posttest results for 1977, the mean score for the experimental group, 82.9, is significantly

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[6] Posttest data were not collected for one of the nonexperienced classes and for two of the experienced classes.

[7] The error in test distribution that invalidated the results of the 1976 tests was discovered too late to permit pretesting another second-grade control group.

TABLE 11

Performance of Experimental and Control Groups on 1977 Second-grade Posttest

| Group | *N* | Estimated mean score[a] | Standard error | 95% confidence interval |
|---|---|---|---|---|
| Experimental, total | 783 | 82.9 | .35 | 82.2–83.6 |
| Nonexperienced | 300 | 78.6 | .50 | 77.6–79.6 |
| Experienced | 483 | 85.6 | .40 | 84.8–86.4 |
| Control | 542 | 74.2 | .40 | 73.4–75.0 |

[a] Maximum score: 125.

higher than that for the control group, 74.2. The table also shows results separately for the two experimental groups, experienced and nonexperienced. The students with two years of radio experience scored significantly higher than those with no previous experience and outscored the control group by more than 10 points.

The project uses a matrix-sampling design for all its tests (see Searle et al., 1976). The scores shown in Table 11 are estimated using procedures described by Sirotnik (1975). Following Sirotnik the 95% confidence intervals are used to examine statistical significance. A mean score that falls outside the 95% confidence interval of another score has only one chance in 20 of being the mean of a sample drawn from the same population. In Table 11 each mean differs significantly at the 5% level from all the others. Thus, the mean score for the experienced group is significantly higher than that for the nonexperienced group, which in turn is significantly higher than that for the control group.

Test results are reported for individual items in Appendix C. Table A in the appendix compares the experimental and control groups; Table B, the two levels of experience. We show a summary comparison of performance of the experimental and control groups by mathematical topic in Table 12. (Note that this table reports mean percentage correct.) The experimental students scored higher than control students on 15 of the 18 topics tested; differences range from 1.0 to 17.8 percentage points. Topics with the greatest differences are vertical subtraction (17.8 percentage points), vertical addition (17.0), and horizontal subtraction (14.2). These topics received the greatest emphasis in the radio lessons. The project also expended considerable effort on fractions, in which the experimental group scored 10.9 percentage points higher than the control students. Special posters were prepared (the only support material developed for second grade) for use during the radio lessons. The experimental classes scored substantially better on this topic (fractions) than the traditional classes. Finally, given the audio presentation of radio, it is not surprising to find that the students in experimental classes performed better than those in control classes on most oral topics. The greatest difference was 7.9 percentage points.

The control group performed substantially better than the experimental group only on geometry (14.6 percentage points higher). This topic, along with measurement (on which the control classes scored 2.7 points higher), was not taught by the radio lessons, but was left to the classroom teacher to present.

TABLE 12

Comparison of 1977 Second-grade Posttest Scores of Experimental and Control Students by Topic

| Topic | Number of items | Mean percentage correct | | Difference |
|---|---|---|---|---|
| | | Experimental | Control | |
| Numeration | 25 | 79.4 | 78.3 | 1.1 |
| Basic concepts | 5 | 41.3 | 39.9 | 1.4 |
| Oral addition | 5 | 80.8 | 75.9 | 4.9 |
| Vertical addition | 10 | 72.9 | 55.9 | 17.0 |
| Horizontal addition | 5 | 71.4 | 65.6 | 5.8 |
| Oral subtraction | 5 | 75.7 | 67.8 | 7.9 |
| Vertical subtraction | 10 | 52.5 | 34.7 | 17.8 |
| Horizontal subtraction | 5 | 65.8 | 51.6 | 14.2 |
| Fractions | 10 | 58.5 | 47.6 | 10.9 |
| Money | 5 | 48.8 | 46.0 | 2.8 |
| Oral multiplication | 3 | 84.8 | 82.0 | 2.8 |
| Vertical multiplication | 5 | 64.4 | 58.6 | 5.8 |
| Oral division | 2 | 56.6 | 48.7 | 7.9 |
| Vertical division | 5 | 63.3 | 56.7 | 6.6 |
| Time | 5 | 47.8 | 46.8 | 1.0 |
| Geometry | 2 | 64.7 | 79.3 | −14.6 |
| Measurement | 3 | 26.4 | 29.1 | −2.7 |
| Word problems | 15 | 66.3 | 66.3 | 0 |

Table 13 shows a similar comparison between nonexperienced and experienced radio students. The experienced students scored higher on 17 of the 18 test topics, with the difference in mean topic score ranging from 1.9 to 25.0 percentage points. The experienced students scored substantially higher on time (25.0), oral subtraction (14.5), measurement (13.8), oral multiplication (12.3), and fractions (8.7). These findings are consistent with the instructional experience of students who had received the first-grade radio lessons, which gave heavier emphasis to the topics of time, measurement, and fractions than did the second-grade lessons; apparently these students remembered what they had learned in first grade. The performance

TABLE 13

Comparison of 1977 Second-grade Posttest Scores of Experienced and Nonexperienced Students by Topic

| Topic | Number of items | Mean percentage correct | | Difference |
|---|---|---|---|---|
| | | Nonexperienced students | Experienced students | |
| Numeration | 25 | 78.1 | 80.3 | 2.2 |
| Basic concepts | 5 | 39.2 | 43.4 | 4.2 |
| Oral addition | 5 | 77.4 | 83.3 | 5.9 |
| Vertical addition | 10 | 71.4 | 74.0 | 2.6 |
| Horizontal addition | 5 | 70.1 | 72.6 | 2.5 |
| Oral subtraction | 5 | 67.1 | 81.6 | 14.5 |
| Vertical subtraction | 10 | 49.8 | 54.5 | 4.7 |
| Horizontal subtraction | 5 | 64.1 | 66.7 | 2.6 |
| Fractions | 10 | 53.2 | 61.9 | 8.7 |
| Money | 5 | 46.2 | 51.0 | 4.8 |
| Oral multiplication | 3 | 76.7 | 89.0 | 12.3 |
| Vertical multiplication | 5 | 60.1 | 67.4 | 7.3 |
| Oral division | 2 | 61.3 | 54.2 | −7.1 |
| Vertical division | 5 | 59.8 | 66.7 | 6.9 |
| Time | 5 | 33.2 | 58.2 | 25.0 |
| Geometry | 2 | 63.8 | 65.7 | 1.9 |
| Measurement | 3 | 18.4 | 32.2 | 13.8 |
| Word problems | 15 | 64.5 | 67.4 | 2.9 |

difference in subtraction may be explained by two factors—the difficulty of the subtraction concept and the emphasis given it in the first-grade lessons. One can contrast subtraction with addition, which is much easier. Although the experienced students did better in oral addition than the nonexperienced, the difference is smaller probably because the addition concept is easier for the students to learn.

The results for oral multiplication provide an interesting case. The experienced children may have had greater success with oral multiplication because of the stress given to understanding the meaning of addition in first grade, since the concept of repeated addition was used to teach multiplication in second grade.

The nonexperienced students outscored the experienced students on only one topic, oral division (by 7.1 percentage points). We have no hypothesis to account for this outcome.

Looking at Tables 12 and 13 together, we notice that the nonexperienced students scored within about a point of the control students on 4 of the 18 topics and lower than the control students on 5 other topics, some not taught by radio. Thus, the performance differences between nonexperienced second graders and those taught by traditional methods are not nearly so great as those found at the first-grade level. However, there is a clear cumulative effect, and experienced students substantially outperform traditional students on almost all topics.

### *Comparison of Radio and Nonradio Urban Students*

We were able to make a different type of performance comparison using a test of addition and subtraction skills designed for another purpose. The full test, which consisted of 150 vertical addition items and 150 vertical subtraction items, was administered to 3,000 students, 500 at each grade level, in Managua primary schools. Several forms of the test were given to second-grade radio students, and in Table 14 their performance is compared with that of the urban population. The performance level of the second-grade radio students is much closer to that of urban students in Grade 3 than in Grade 2; clearly, the radio students are performing better in addition and subtraction than are their second-grade urban counterparts.

## 3. COMPARISON OF PROGRAMS FOR GRADES 1 AND 2

The major difference in design between the instructional programs for first and second grades is that worksheets are not used in second grade. We do not dispute the claim that worksheets or other individual supplementary materials enhance learning, and our experience has convinced us that their use makes it easier to write

TABLE 14

Comparison of Radio Rural (Masaya) and Nonradio Urban (Managua) Students on Addition and Subtraction Items

| Item type | Mean percentage correct | | |
|---|---|---|---|
| | Radio students (Masaya) | Nonradio students (Managua) | |
| | Grade 2 | Grade 2 | Grade 3 |
| Addition | 72.6 | 60.3 | 74.5 |
| Subtraction | 47.7 | 34.7 | 49.6 |

lessons. Nevertheless, we felt that in a country with few resources to devote to education, the cost of such materials is prohibitive. In abandoning worksheets we had no intention of abandoning all supplementary visual materials—only those distributed to individual children. Our plan was to use chalkboard illustrations that would be copied by the teacher from the teacher's guide and, occasionally, specially prepared posters.

### *Purposes of the Worksheet*

Before making the decision to substitute other types of displays, we reviewed the first-grade curriculum to determine the proportions of different activities that used worksheets, which serve two basic purposes: They are a source of visual illustrations and provide a place for students to record their responses. In some cases these two uses are independent; in others they are closely related. We will illustrate these functions with some specific examples.

1. A lesson segment that introduces the concepts of *more* and *less* uses the worksheet to show a series of pairs of baskets containing different numbers of fruits. In a typical exercise the child is asked to circle the basket that contains the most coconuts. Note that although the child does record his answer on the worksheet, this use is secondary and nonessential. Primarily, the worksheet provides the picture; the child could just as well have responded by pointing to his choice or by orally answering the question "Which basket has more, the first or the second?"

Most of these exercises could be illustrated on the chalkboard by the teacher, following directions in the guide. The drawings would have to be simpler than those printed on the worksheets, but we have observed that with suitable models the teachers can produce such drawings. Of course, the second-grade lessons would also use fewer pictures than first-grade lessons. The topics for which we had some doubts about relying on chalkboard illustrations were fractions, area, and other measurements, largely because we felt that many teachers themselves do not understand these concepts well enough to illustrate them. (Our doubts are not abstract but are based on observations of the illustrations teachers use in traditional classes and of the illustrations they draw following models provided by us in teacher's guides.) For these topics we felt that we should supply posters.

2. In teaching the numerals we give many exercises in which the children write numerals from dictation. The worksheet in this case has no illustrative material. Exercises of this type can be worked just as well in a notebook, which each child has. Thus, no loss is incurred in eliminating the worksheet for this type of exercise.

3. In some printed exercises the position of the child's written response depends on the format of the graphic stimulus. A closer inspection of these exercises revealed that the majority are computation exercises, such as

$$\begin{array}{r} 2 \\ +5 \\ \hline \end{array} \qquad \begin{array}{r} 59 \\ -28 \\ \hline \end{array} \qquad \begin{array}{r} 32 \\ \times\ 2 \\ \hline \end{array}$$

where it is essential that the stimulus and response be on the same piece of paper. However, we saw no reason why second graders could not copy such exercises from the chalkboard into their notebooks if the teacher copied the exercises from the guide in advance. Besides computation exercises of the types shown above, this group also contains exercises on sequences, predecessors, and successors. None of these poses any great problem since they also can be written on the chalkboard.

The allocation of worksheet space to the three uses described here was assessed by measuring the appropriate areas on every 10th worksheet from the first-grade lessons. The results are shown in Table 15, grouped into early, middle, and late lessons. Early in the year about half of the worksheet was used for illustrative purposes only; this dropped to zero by the end of the year. The striking increase in the area of the worksheet devoted to illustrative material requiring a student response reflects in part the increased attention to computational algorithms. This survey of the use of worksheet space supported our contention that second-grade lessons could be written without student worksheets.

TABLE 15

Allocation of Worksheet Space to Exercise Types[a]

| Range of lessons sampled | Type 1 | | Type 2 | | Type 3 | |
|---|---|---|---|---|---|---|
| | Square inches | % | Square inches | % | Square inches | % |
| 10–50 | 56.0 | 43 | 13.5 | 10 | 61.0 | 48 |
| 60–100 | 11.4 | 8 | 31.8 | 22 | 101.7 | 70 |
| 110–150 | 0 | 0 | 5.1 | 4 | 139.9 | 96 |

[a] Exercise types are described in text.

Weighing advantages and disadvantages, we concluded that using the chalkboard and notebooks instead of worksheets was clearly feasible, except for a few topics (particularly fractions) about which we had serious doubts. Thus, we used the chalkboard and notebooks throughout the year, supplemented by a set of 22 posters (9 in. by 12 in.) illustrating area and fractions. We now believe that even fewer posters would have served, had we planned the instruction to make maximum use of the most essential ones. There is undoubtedly some diminution in the achievement levels in certain topics, but we feel that there would be no measurable loss in the most important concepts, including counting, numerals, order relations, addition, subtraction, multiplication, division, and oral word problems.

### *Other Differences*

In addition to eliminating worksheets in second grade, we made a number of stylistic and pedagogical changes. These were not all made abruptly between years but were incorporated one at a time as we obtained test and observational data that sharpened our understanding of how to prepare more effective and more entertaining lessons. There has been a consistent trend from the beginning of first grade—which continues in the production of third-grade lessons—to reduce the amount of talk in the lessons. We use fewer words per minute, fewer words per sentence, less time per uninterrupted message, and, as a result, obtain a higher response rate from the children. We also tend to address more speech directly to the children and to reduce the amount of dialogue between characters. Transitions between lesson segments are now more often musical than verbal, and entertainment segments are also less verbal, relying instead on music or physical activity, both of which seem to be more appealing to the children than more verbal diversions like puns, poems, and stories.

We are also constantly concerned with rhythm and timing—in particular, the rate of change of topics, the speed of speech, and the amount of time allowed in pauses for responses. Each of these must be continuously adapted to the level of development of the children, with the general trend being to step up the pace as the children gain experience. Pauses for writing numerals, solving exercises, and so on, are particularly critical, since pauses that are too long result in inattention and pauses that are too short lead to frustration. We do not yet have a comprehensive formula for determining pauses but have developed fairly precise standards for dozens of different types of responses at different levels of student development. One noticeable change between first and second grade is that in second grade we use silent pauses with no music or sound effects that might distract the children while they are thinking. However, we have learned that broadcasting "dead air" is frowned on by professional broadcasters and we are currently experimenting with the use of very quiet background music during these pauses to see if we can circumvent this objection without degrading the pedagogical quality of the lesson.

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## APPENDIX A

### EXERCISE CLASSES FOR SECOND GRADE, 1976

| Exercise class | | Lesson[a] |
|---|---|---|
| Symbol | Description | |
| NC1 | Counting by 1's to 50 | 1 |
| NC2 | Dozen | 1 |
| NC3 | Counting by 1's | 1 |
| NC4 | Counting by 10's to 100 | 6 |
| NC6 | Counting by 100's to 1,000 | 16 |
| NC7 | Counting by 10's and 1's | 11 |
| NC8 | Counting on/with objects to 99 | 16 |
| NC9 | Counting by 100's, 10's, and 1's | 23 |
| NC10 | Regrouping 1's into 10's | 16 |
| NC11 | Counting by 2's to 20 | 151 |
| NC12 | Counting by 5's, with objects | 96 |
| NE1 | Reading and writing numerals to 99 | 1 |
| NE2 | Reading and writing numerals to 999 | 11 |
| NE3 | 10's and 1's digits | 14 |
| NE4 | 100's digit | 26 |
| NE5 | Reading and writing numerals to 9,999 | 72 |
| NE6 | 1,000's digit | 83 |
| NM1 | Oral problems, concept of more | 24 |
| NM2 | Greater than, to 20 | 34 |
| NM3 | Greater than, to 99 | 37 |
| NM4 | Less than, to 99 | 76 |
| NM5 | Greater than and less than, to 999 | 86 |
| NM6 | Greater than and less than, to 9,999 | 97 |
| NS1 | Sequences, numeration by 1's | 101 |
| OR1 | Ordinals, concept of 1st through 6th | 116 |
| OR2 | Ordinals, reading and writing numerals 1st through 6th | 121 |
| OR3 | Ordinals, concept of 7th through 12th | 126 |
| OR4 | Ordinals, reading and writing numerals 7th through 12th | 131 |
| OR5 | Order of ordinals | 156 |
| FR1 | Concept of fractions, 1/2 and 1/4 | 66 |
| FR2 | Reading and writing numerals, 1/2 and 1/4 | 72 |
| FR3 | Concept of fractions, $n/m$, $n \leq m$, $m = 2, 3, 4, 5$ | 77 |
| FR4 | Reading and writing numerals, $n/m$, $n \leq m$, $m = 2, 3, 4, 5$ | 81 |
| FR5 | Fractions, relationships, $>$, $<$, $=$, equal denominators | 131 |

| Exercise class | | Lesson[a] |
|---|---|---|
| Symbol | Description | |
| FR6 | Fractions, relationships, >, <, =, heterogenous | 154 |
| FR7 | Mixed numbers | 124 |
| FR8 | Whole numbers and fractions, relationships, <, > | 144 |
| FR9 | Concept of fractions, $n/m$ ($m \leq 10$, $n \leq m$) | 86 |
| FR10 | Reading and writing numerals, $n/m$, $n \leq m$ | 111 |
| FR11 | Improper fractions, $n/m$, $n \geq m$ | 120 |
| FR12 | Oral problems with mixed numbers | 173 |
| AO1 | Oral addition, $a + b \leq 10$ | 1 |
| AO2 | Oral addition, $a + b \geq 11$, counting on | 12 |
| AO3 | Oral addition, $a + b + c \leq 10$, $a + b + c + d \leq 10$ | 6 |
| AO4 | Oral addition, $a0 + b0 \leq 90$ | 31 |
| AO5 | Oral addition, $a0 + b$ | 7 |
| AO6 | Oral addition, $a00 + b00 \leq 900$ | 65 |
| AO7 | Oral addition, $a00 + bc$ | 21 |
| AO8 | Oral addition, $ab + c < 100$, counting on | 46 |
| AO9 | Oral addition, $a0 + b + c$ ($b + c \leq 9$) | 58 |
| AO11 | Oral addition, $a + b + c$, $a + b + c + d > 10$ | 47 |
| AO12 | Oral addition, $a00 + b0 + c$, $a00 + bc$ | 66 |
| AO13 | Oral addition, $a + b0$ | 36 |
| AV1 | Vertical addition, $a + b \leq 9$ | 2 |
| AV2 | Vertical addition, $ab + cd$, without carry, without passing | 11 |
| AV3 | Vertical addition, $ab + c$, $a + bc$, without carry | 26 |
| AV4 | Vertical addition, $abc + def$, without carry, without passing | 21 |
| AV5 | Vertical addition, $abc + de$, $abc + d$, without carry | 61 |
| AV6 | Vertical addition, $abcd + efgh$, without carry, without passing | 121 |
| AV7 | Vertical addition, $abcd + efg$, or $ef$, or $e$ without carry | 126 |
| AV8 | Vertical addition, $a + b + c \leq 9$ | 26 |
| AV9 | Vertical addition, $ab + cd$, with carry, without passing | 46 |
| AV10 | Vertical addition, $ab + c$, without carry, without passing | 46 |
| AV11 | Vertical addition, $abc + def$, carry once, without passing | 81 |
| AV12 | Vertical addition, $abc + def$, carry twice, without passing | 96 |
| AV13 | Vertical addition, $abc + de$, $abc + d$, with carry, without passing | 91 |
| AV14 | Vertical addition, $abcd + efgh$, carry once, without passing | 131 |
| AV15 | Vertical addition, $abcd + efgh$, carry twice, without passing | 138 |
| AV16 | Vertical addition, $abcd + efgh$, carry 3 times, without passing | 141 |
| AV17 | Vertical addition, $abcd + efg$, $abcd + ef$, $abcd + e$, carry once, without passing | 136 |

| Exercise class | | Lesson[a] |
|---|---|---|
| Symbol | Description | |
| AV18 | Vertical addition, abcd + efg, abcd + ef, abcd + e, carry twice, without passing | 146 |
| AV19 | Vertical addition, $a + b \leq 10$ | 56 |
| AV20 | Vertical addition, ab + cd, without carry, with passing | 66 |
| AV21 | Vertical addition, abc + def, without carry, with passing | 76 |
| AV23 | Vertical addition, ab + cd, with carry, with passing | 91 |
| AV24 | Vertical addition, ab + c, with carry, with passing | 111 |
| AV25 | Vertical addition, abc + def, with carry, with passing | 111 |
| AV26 | Vertical addition, abc + de, abc + d, with carry, with passing | 116 |
| AV27 | Vertical addition, ab + cd + ef, ab + cd + e, carry once, without passing | 92 |
| AV28 | Vertical addition, abc + def + ghi, carry once | 101 |
| AV29 | Vertical addition, ab + cd + ef, ab + cd + e, carry twice | 106 |
| AV30 | Vertical addition, abc + def + ghi, carry once and/or twice | 111 |
| AV31 | Vertical addition, a + b, from dictation | 42 |
| AV32 | Vertical addition, ab + cd, ab + c, from dictation | 81 |
| AV33 | Vertical addition, abc + def, abc + de, abc + d, from dictation, carry once, without passing | 126 |
| AV34 | Vertical addition, ab + cd + ef, ab + cd + e, without carry | 91 |
| AV35 | Vertical addition, abc + def + ghi, without carry, without passing | 102 |
| AV36 | Vertical addition, $a + b + c \geq 20$ | 103 |
| AV37 | Vertical addition, ab + c, from dictation, without carry | 172 |
| AH1 | Horizontal addition, $a + b \leq 10$ | 13 |
| AH2 | Horizontal addition, $a + b \geq 11$, counting on | 21 |
| AH3 | Horizontal addition, $a + b + c \leq 10$, $a + b + c + d \leq 10$ | 16 |
| AH4 | Horizontal addition, $a0 + b0 \leq 90$ | 36 |
| AH5 | Horizontal addition, a0 + b, a + b0 | 41 |
| AH6 | Horizontal addition, $a00 + b00 \leq 900$ | 69 |
| AH7 | Horizontal addition, a00 + bc | 71 |
| AH8 | Horizontal addition, a + b + c, a + b + c + d | 51 |
| AH9 | Horizontal addition, $a0 + b0 + c < 100$ | 56 |
| AH10 | Horizontal addition, a0 + b + c ($b + c \leq 9$) | 61 |
| AH11 | Horizontal addition, a + b + c, $a + b + c + d < 10$ | 62 |
| AH12 | Horizontal addition, a00 + b0 + c | 74 |
| SO1 | Oral subtraction, a − b, $a \leq 10$ | 1 |
| SO2 | Oral subtraction, 1a − b, $b > a$ | 11 |
| SO3 | Oral subtraction, ab − b | 42 |
| SO4 | Oral subtraction, a0 − b0 | 36 |
| SO5 | Oral subtraction, a00 − b00 | 66 |
| SO6 | Oral subtraction, abc − bc | 77 |
| SO7 | Oral subtraction, ab − a0 | 46 |

| Exercise class | | Lesson[a] |
|---|---|---|
| Symbol | Description | |
| SO8 | Oral subtraction, $ab - c$, $c \leq b$ | 21 |
| SO9 | Oral subtraction, $a0 - 1$ | 156 |
| SV1 | Vertical subtraction, $a - b$ | 6 |
| SV2 | Vertical subtraction, $1a - b$, $b > a$ | 70 |
| SV3 | Vertical subtraction, $ab - cd = ef$, without borrow | 26 |
| SV4 | Vertical subtraction, $ab - c = de$, without borrow | 31 |
| SV5 | Vertical subtraction, $ab - ad = e$ | 73 |
| SV6 | Vertical subtraction, $abc - def = ghi$, without borrow | 56 |
| SV7 | Vertical subtraction, $abc - de = fgh$, without borrow | 61 |
| SV8 | Vertical subtraction, $abc - d = efg$, without borrow | 111 |
| SV9 | Vertical subtraction, $abc - ade = fg$, without borrow | 101 |
| SV10 | Vertical subtraction, $abc - abd = e$, without borrow | 108 |
| SV18 | Vertical subtraction, $ab - cd = ef$, with borrow | 96 |
| SV19 | Vertical subtraction, $ab - cd = e$, $ab - c = de$, with borrow | 127 |
| SV20 | Vertical subtraction, $abc - def = ghi$, with borrow | 126 |
| SV21 | Vertical subtraction, $abc - de = fgh$, borrow from the 10's or 100's | 131 |
| SV22 | Vertical subtraction, $abc - d = efg$, with borrow | 136 |
| SV27 | Vertical subtraction, $a - b$, from dictation | 67 |
| SV28 | Vertical subtraction, $ab - cd$, $ab - c$, from dictation, without borrow | 82 |
| SV31 | Vertical subtraction, $ab - c$, from dictation, with borrow | 166 |
| SV33 | Justifying subtraction, vertical, without borrow | 66 |
| SV34 | Vertical subtraction, $abc - def = ghi$, borrow from the 10's or 100's | 134 |
| SV35 | Vertical subtraction, $abc - def = gh$, borrow from the 100's | 132 |
| SV36 | Vertical subtraction, $abc - de = fg$, borrow from the 100's | 136 |
| SV37 | Vertical subtraction, $abc - def = gh$, borrow twice | 142 |
| SV38 | Vertical subtraction, $a0b - cde = fgh$, complex borrow | 166 |
| SV39 | Vertical subtraction, $abc - de = fgh$, $abc - de = fg$, borrow twice | 161 |
| SV40 | Vertical subtraction, $a0 - 1$ | 173 |
| SH1 | Horizontal subtraction, $m - b$, $m \leq 10$ | 17 |
| SH2 | Horizontal subtraction, $1a - b$, $b > a$ | 23 |
| SH3 | Horizontal subtraction, $ab - b$ | 46 |
| SH4 | Horizontal subtraction, $a0 - b0$ | 42 |
| SH5 | Horizontal subtraction, $a00 - b00$ | 71 |
| SH6 | Horizontal subtraction, $abc - bc$ | 86 |
| SH7 | Horizontal subtraction, $ab - a0$ | 51 |
| SH8 | Horizontal subtraction, $ab - c$, $c \leq b$ | 27 |

| Exercise class | | Lesson[a] |
|---|---|---|
| Symbol | Description | |
| CO1 | Oral addition and subtraction combinations, $a \pm b \pm c$ | 21 |
| CO2 | Oral addition and subtraction combinations, $ab \pm c \pm d$ | 64 |
| CO3 | Oral addition and subtraction combinations, $a \pm b \pm c \pm d$ | 100 |
| CH1 | Horizontal addition and subtraction, $a \pm b \pm c$ | 116 |
| MO1 | Oral multiplication, $a \times b \leq 9$ | 31 |
| MO2 | Oral multiplication, $a0 \times b$, $a \times b0$, $a \times b \leq 9$ | 76 |
| MO3 | Oral multiplication, $a00 \times b$ | 82 |
| MO4 | Oral multiplication, $a \times b \leq 25$ | 41 |
| MO5 | Oral multiplication, $a \times b \leq 81$ | 101 |
| MO6 | Oral multiplication, $a \times 0$, $0 \times a$ | 62 |
| MV1 | Vertical multiplication, $a \times b \leq 9$ | 36 |
| MV2 | Vertical multiplication, $a \times b \leq 25$ | 61 |
| MV3 | Vertical multiplication, $a \times b \leq 81$ | 108 |
| MV4 | Vertical multiplication, $ab \times c$, without carry, without passing | 56 |
| MV5 | Vertical multiplication, $ab \times c$, $a \times b \leq 25$, without carry | 91 |
| MV6 | Vertical multiplication, $ab \times c$, $a \times c \leq 81$, without carry | 116 |
| MV7 | Vertical multiplication, $abc \times d$, without carry, without passing | 71 |
| MV8 | Vertical multiplication, $ab \times c$, $a \times b \leq 25$, $b \times c \leq 25$, with carry | 136 |
| MV9 | Vertical multiplication, $ab \times c$, with carry and passing | 141 |
| MV10 | Vertical multiplication, $abc \times d$, carry once | 146 |
| MV11 | Vertical multiplication, $abcd \times e$, carry once, without passing | 151 |
| MV12 | Vertical multiplication, $abcd \times e$, carry twice (nonconsecutive), without passing | 156 |
| MV13 | Vertical multiplication, $abc \times c$, carry twice | 153 |
| MV14 | Vertical multiplication, $abcd \times e$, carry twice (consecutively), without passing | 162 |
| MV16 | Vertical multiplication, $a \times b \leq 9$, from dictation | 79 |
| MV17 | Vertical multiplication, $a \times b \leq 25$, from dictation | 86 |
| MV18 | Vertical multiplication, $a \times b \leq 81$, from dictation | 121 |
| MV19 | Vertical multiplication, $ab \times c$, from dictation, without carry | 126 |
| MV20 | Vertical multiplication, $ab \times c$, from dictation, with carry | 146 |
| MV21 | Vertical multiplication, $abc \times d$, from dictation, with carry | 156 |
| MH1 | Horizontal multiplication, $a \times b \leq 9$ | 41 |
| MH2 | Horizontal multiplication, $a0 \times b \leq 90$ | 84 |

| Exercise class | | Lesson[a] |
|---|---|---|
| Symbol | Description | |
| MH3 | Horizontal multiplication, $a00 \times b \leq 900$ | 87 |
| MH4 | Horizontal multiplication, $a \times b \leq 25$ | 51 |
| MH5 | Horizontal multiplication, $a \times b \leq 81$ | 106 |
| DO1 | Oral division, $a \div b$, $b = 2, 3, 4$, measurement | 103 |
| DO2 | Oral division, $ab \div c \leq 5$, $ab$ divisible by $c$, $c = 2, 3, 4, 5$ | 156 |
| DO4 | Oral division, $ab \div c \leq 4$, $c = 3, 4, 5$, with remainder | 171 |
| DV1 | Vertical division, $a \div b$, $b = 2, 3, 4$ | 116 |
| DV2 | Vertical division, $ab \div c$, $a$ divisible by $c$, $b$ divisible by $c$ | 147 |
| DV4 | Vertical division, $ab \div c$, $c = 2, 3, 4, 5$, $a$ divisible by $c$, $b > c$ | 151 |
| DV5 | Vertical division, $abc \div d$, $d = 2, 3, 4, 5$, $a$ divisible by $d$, $b$ divisible by $d$ | 157 |
| DV7 | Vertical division, $a \div b$, $b = 2, 3, 4$, from dictation | 146 |
| DV8 | Vertical division, $ab \div c$, $c = 2, 3, 4, 5$, $a$ divisible by $c$, $b$ divisible by $c$, from dictation | 154 |
| DV9 | Vertical division, $ab \div c$, $a$ divisible by $c$, $b > c$, $c = 2, 3, 4, 5$ | 151 |
| AF1 | Addition of fractions, $a/b + c/b$, $a + c \leq b$, $b = 2, 3, 4, 5, 10$ | 113 |
| AF2 | Addition of fractions, $a/b + c/b + d/b$, $b = 2, 3, 4, 5, 10$ | 121 |
| AF3 | Addition of fractions, $a + b/c$, $a\ b/c = 1/c + 1/c$ | 129 |
| SF1 | Subtraction of fractions, $a/b - c/b$, $a/b$ and $c/b \leq 1$, $b = 2, 3, 4, 5, 10$ | 116 |
| PA1 | Oral addition problems, $a + b \leq 10$ | 4 |
| PA2 | Oral addition problems, $a + b \geq 11$ | 27 |
| PA3 | Oral addition problems, $a + b + c \leq 10$, $a + b + c + d \leq 10$ | 36 |
| PA4 | Oral addition problems, $a0 + b0$ | 42 |
| PA5 | Oral addition problems, $a0 + b$ | 31 |
| PA6 | Oral addition problems, $a00 + b00 \leq 900$ | 70 |
| PA7 | Oral addition problems, $a00 + bc$, $a00 + b$ | 43 |
| PA8 | Oral addition problems, $ab + c < 100$ | 51 |
| PA9 | Oral addition problems, $a0 + b0 + c < 100$ | 58 |
| PA10 | Oral addition problems, $a0 + b + c$ $(b + c \leq 9)$ | 65 |
| PA11 | Oral addition problems, $a + b + c$, $a + b + c + d$ | 55 |
| PA12 | Oral addition problems, $a00 + b0 + c$ | 71 |
| PA13 | Oral addition problems, $a + b0$ | 46 |
| PA14 | Oral addition problems, copied exercises, $a + b$ | 72 |

| Exercise class | | Lesson[a] |
|---|---|---|
| Symbol | Description | |
| PA15 | Oral addition problems, copied exercises, $ab + cd$, $ab + c$, without passing | 113 |
| PA16 | Oral addition problems, $abc + def$, $abc + de$, $abc + d$, written | 143 |
| PS1 | Oral subtraction problems, $a - b$, $b \leq 19$ | 7 |
| PS2 | Oral subtraction problems, $1a - b$, $b > a$ | 31 |
| PS3 | Oral subtraction problems, $ab - b$ | 54 |
| PS4 | Oral subtraction problems, $a0 - b0$ | 47 |
| PS5 | Oral subtraction problems, $a00 - b00$ | 81 |
| PS6 | Oral subtraction problems, $abc - bc$ | 88 |
| PS7 | Oral subtraction problems, $ab - a0$ | 59 |
| PS8 | Oral subtraction problems, $ab - c$, $c \leq b$ | 36 |
| PS9 | Oral subtraction problems, $a - b$, copied | 80 |
| PS10 | Oral subtraction problems, $ab - cd$, $ab - c$, without borrow, written | 104 |
| PS11 | Oral subtraction problems, $abc - def$, $abc - ef$, $abc - f$, without borrow, written | 143 |
| PS12 | Oral subtraction problems, $ab - cd$, $ab - c$, with borrow, written | 132 |
| PS13 | Oral subtraction problems, $abc - def$, $abc - de$, $abc - d$, with borrow, written | 144 |
| PM1 | Oral multiplication problems, $a \times b \leq 9$ | 36 |
| PM2 | Oral multiplication problems, $a0 \times b$ $(a \times b \leq 9)$ | 86 |
| PM3 | Oral multiplication problems, $a00 \times b$ $(a \times b \leq 9)$ | 97 |
| PM4 | Oral multiplication problems, $a \times b \leq 25$ | 56 |
| PM5 | Oral multiplication problems, $a \times b \leq 81$ | 114 |
| PM6 | Oral multiplication problems, $a \times b \leq 9$, written | 93 |
| PM7 | Oral multiplication problems, $a \times b \leq 25$, written | 101 |
| PM8 | Oral multiplication problems, $a \times b \leq 81$, writing mathematical expressions | 140 |
| PM9 | Oral multiplication problems, $ab \times c$, without carry, written | 145 |
| PM10 | Oral multiplication problems, $ab \times c$, with carry, written | 154 |
| PM11 | Oral multiplication problems, $abc \times d$, with carry, written | 161 |
| PD1 | Oral division problems, $a \div b$, $a$ divisible by $b$, $b = 2, 3, 4$ | 65 |
| PD2 | Oral division problems, $ab \div c \leq 4$, $ab$ divisible by $c$, $c = 3, 4, 5$ | 121 |
| PD3 | Oral division problems, $a \div b$, $b = 2, 3, 4$, written | 149 |
| PD4 | Oral division problems, $ab \div c$, $c = 2, 3, 4, 5$, $a$ divisible by $c$, $b$ divisible by $c$, written | 160 |

| Exercise class | | Lesson[a] |
|---|---|---|
| Symbol | Description | |
| MB1 | Changing money into different denominations | 116 |
| MB2 | Amount symbols for money | 128 |
| MB3 | Value of a set of bills and/or coins | 132 |
| MB4 | Oral money problems, buying and giving change | 136 |
| MT1 | Telling time, hour, half-hour, quarter-hour | 91 |
| MT2 | Minutes in an hour, half-hour, quarter-hour | 96 |
| MT3 | Telling time, hours in a day | 112 |
| MT4 | Names of days of the week | 126 |
| MT5 | Names of months of the year | 135 |
| MT6 | Relation between days and weeks, months and years | 136 |
| MT7 | Ordinals for the months | 146 |
| MT8 | Oral time problems, hour, elapsed time | 121 |
| ML1 | Length, cm | 47 |
| ML2 | Length, cm, m, km | 51 |
| ML3 | Length, comparison and equivalence, >, <, =, cm, m, km | 96 |
| ML4 | Length, appropriate units and estimations | 66 |
| ML5 | Length, inch, foot, yard | 56 |
| ML6 | Length, comparison | 76 |
| ML7 | Length, appropriate units and estimation, inch, foot, yard | 91 |
| ML9 | Length, oral problems, | 108 |
| ML10 | Area, unstandardized units | 26 |
| ML11 | Area, cm, square inches | 61 |
| MP1 | Concept of weight, with objects, use of "heavier than" and "lighter than" | 96 |
| MP2 | Weight, pound, ounce, quintal, arroba | 102 |
| MP3 | Weight, comparison and equivalences, pound and ounce | 111 |
| MP4 | Weight, concept of gram and kilogram | 126 |
| MP5 | Weight, comparison and equivalences, <, >, =, all units | 131 |
| MP6 | Weight, appropriate units and weight estimation | 133 |
| MP7 | Oral weight problems | 121 |
| MC1 | Capacity, concept of liter, half-liter, cup | 122 |
| MC2 | Capacity, comparison and equivalences, <, >, =, liter, cup | 137 |
| MC3 | Capacity, gallon, half-gallon, quarter-gallon | 151 |
| MC4 | Capacity, comparison and equivalences, >, <, = | 162 |
| MC5 | Oral capacity problems | 156 |
| MC6 | Capacity, appropriate units and capacity estimations | 146 |
| GE1 | Geometric figures | 27 |

[a] Numbers indicate lesson in which exercise class first occurs.

## APPENDIX B

## RADIO MATHEMATICS PROJECT: LESSON 171

**PROGRAM:** Mathematics by Radio **YEAR:** 1976
**GRADE:** 2 **LESSON NUMBER:** 171 **VERSION:** 1
**DURATION:** 28:50
**DATE OF RECORDING:** November 9, 1976
**RECORDED AT:** Radio Corporación, Managua, Nicaragua

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**VOICES:**

MONSTER
LITTLE GIRL 1
LITTLE GIRL 2
CHORUS
LITA
RAYMOND
LITTLE BOY
LITTLE GIRL
ANNOUNCER

## EFFECTS:

**MUSIC:** THEME
**MUSIC:** "GOOD MORNING" *(Recorded)*
**MUSIC:** "THE WEEK" *(Tape of little girls)*
**MUSIC:** TRANSITION TO ORAL SEGMENT
**JINGLE:** "ONE HOUR" *(Recorded)*
**JINGLE:** "HALF HOUR" *(Recorded)*
**MUSIC:** TRANSITION TO JOKE
**MUSIC:** TRANSITION TO GAME
**MUSIC:** "THE ACUARTILLADO" (SANTO DOMINGO)
**SOUND:** GUITAR *(Studio)*
**SOUND:** PEOPLE RUNNING *(Studio)*
**SOUND:** DRUM *(Studio)*
**SOUND:** MARIMBA *(Studio)*
**SOUND:** TRUMPET *(Studio)*
**MUSIC:** TRANSITION TO NOTEBOOKS
**MUSIC:** TRANSITION TO RIDDLE
**SOUND:** DRUM *(1024, A - 2)*
**SOUND:** TRUMPET *(1015, A - 7)*
**SOUND:** VOICES *(1018, B - 17)*
**SOUND:** MOTORCYCLES *(1029, B - 12)*
**EFFECT:** HARP
**SOUND:** MURMUR *(1021, A - 17)*
**MUSIC:** "MULTIPLICATION" *(Recorded)*

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**MUSIC:** THEME
*(Fade in and under)*

**ANNOUNCER:** The Radio Mathematics Project presents Lesson 171 of the series "In the Land of Numbers." The mathematics program is specially designed for elementary school, second grade. Today, Lesson 171.

**MUSIC:** THEME
*(Fade up 5 sec. and under)*

**ANNOUNCER:** Now we'll give the class time to prepare for Lesson 171.

**MUSIC:** THEME
*(Fade up and under)*

**ANNOUNCER:** Today, Lesson 171.

**MUSIC:** THEME

**ANNOUNCER:** Attention—there are 10 seconds left before starting Lesson 171. 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, go!

**MUSIC:** GOOD MORNING
*(Recorded)*

**CHILDREN:** Good morning, good morning.

**OTHER CHILDREN:** How are you, how are you?

**CHILDREN:** We are very happy, we are very happy.
We are fine, we are fine.

**MONSTER:** *(continues singing)* We are fine, we are fine. Tum-de-dum.

**LITTLE GIRL 1:** Now, now, Number Monster! The song is over.

**MONSTER:** That's too bad! I like to sing . . .

**LITTLE GIRL 2:** Yes, we all like to sing. But don't worry. We can sing some more.

**CHORUS:** *(not together)* Yes, yes, let's sing.

**LITA:** Okay. Get ready. We're going to sing "The Week."

**MUSIC:** THE WEEK
*(Tape of little girls)*

Monday a baby girl was born.
Tuesday she was baptized.
Wednesday she went to school.
Thursday she graduated.
Friday she was already old.
Saturday she died.
But Sunday the child was reborn.

**MÚSICA:** TEMA

**LOCUTOR:** El Proyecto Matemática por Radio presenta la Lección 171 de la serie: "En el país de los números." El programa de matemática especialmente diseñado para el segundo grado de educación primaria. Hoy la Lección 171.

**MÚSICA:** TEMA
*Sube y baja a fondo*

**LOCUTOR:** Ahora damos tiempo para que la clase se prepare para la Lección 171.

**MÚSICA:** TEMA
*Sube*

**LOCUTOR:** Hoy, Lección 171.

**MÚSICA:** TEMA
*Sube*

**LOCUTOR:** Atención, faltan diez segundos para comenzar la Lección 171. 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, ya!

**MÚSICA:** BUENOS DÍAS
*(Grabada)*

**NIÑOS:** Buenos días, buenos días.

**OTROS NIÑOS:** ¿Cómo están? ¿Cómo están?

**NIÑOS:** Estamos muy alegres, estamos muy alegres.
Estamos bien, estamos bien.

**MONSTRUO:** *(sigue cantando)* Estamos bien, estamos bien. Lari ra rá.

**NIÑA 1:** Ya, ya, ¡numermonstruo! Ya terminó la canción.

**MONSTRUO:** ¡Qué lástima! Tanto que me gusta cantar . . .

**NIÑA 2:** Sí, a todos nos gusta cantar. Pero yo creo que no hay problema, podemos hacerlo.

**CORO:** *(en desorden)* Sí, sí, ¡cantemos!

**LITA:** Bien. Prepárense. Vamos a cantar "La Semana."

**MÚSICA:** LA SEMANA
*(Cinta niñas)*

El lunes nació una niña.
El martes se bautizó.
El miércoles a la escuela.
Y el jueves se recibió.
El viernes ya estaba vieja.
Y el sábado se murió.
Pero el domingo de nuevo la niña resucitó.

**MUSIC:** TRANSITION TO ORAL SEGMENT
*Mix to*

**JINGLE:** AN HOUR
*(Recorded)*

The ticktock of the clock does remind us
The hours are something we must know.
An hour is sixty whole minutes.
Sixty minutes is an hour entire.
*(spoken)*
One hour, sixty minutes.
One hour, sixty minutes.

**ALL:** Let's start working.
**LITA:** Children, get ready to talk about time . . .
**RAYMOND:** Listen carefully . . . don't answer ahead of time.
**LITA:** An hour has sixty minutes.
**RAYMOND:** Yesterday, Rosa mended socks for sixty minutes.
**LITA:** Children, Rosa mended socks for an hour, or more?
**CHORUS:** An hour.
**RAYMOND:** Yes, an hour. Because an hour has sixty minutes.
**LITA:** José has been doing his homework for fifty minutes.
**RAYMOND:** Children, has he been working an hour, or less?
**CHORUS:** Less.
**LITA:** Less than an hour. Because an hour has sixty minutes.
**JINGLE:** HALF HOUR
*(Recorded)*

The ticktock of the clock does remind us
That the hours are something we must know.
A half-hour is thirty minutes.
Thirty minutes is a half-hour.
*(spoken)*
A half-hour is thirty minutes.
A half-hour is thirty minutes.

**RAYMOND:** Let's go on with the half-hour.
**LITA:** A half-hour has thirty minutes.
**RAYMOND:** Children, Carlos studied for forty minutes.
**LITA:** Tell me, did he study for a half-hour, or more?

**MÚSICA:** TRANSICIÓN A SEGMENTO ORAL
*(Sigue)*

**CANCIÓN:** UNA HORA
*(Grabada)*

El tic tac del reloj nos recuerda
que las horas débemos saber.
Una hora sesenta minutos.
Sesenta minutos una hora es.
*(apagando)*
Una hora sesenta minutos.
Una hora sesenta minutos.

**TODOS:** Empecemos a trabajar.

**LITA:** Niños, atentos que vamos a las medidas a tiempo . . .

**RAMÓN:** Escuchen bien . . . no se adelanten a contestar.

**LITA:** Una hora tiene sesenta minutos.

**RAMÓN:** Ayer, Rosa zurció calcentines durante sesenta minutos.

**LITA:** Niños, Rosa zurció, ¿una hora o más?

**CORO:** Una hora.

**RAMÓN:** Sí, una hora. Porque una hora tiene sesenta minutos.

**LITA:** José tiene cincuenta minutos de estar haciendo sus tareas.

**RAMÓN:** Niños, ¿tiene una hora o menos?

**CORO:** Menos.

**LITA:** Menos de una hora. Porque una hora tiene sesenta minutos.

**CANCIÓN:** MEDIA HORA
*(Grabada)*

El tic tac del reloj nos recuerda
que las horas débemos saber.
Media hora son treinta minutos.
Y treinta minutos media hora es.
*(apagando)*
Media hora son treinta minutos.
Media hora trienta minutos.

**RAMÓN:** Vamos con la media hora.

**LITA:** Media hora tiene treinta minutos.

**RAMÓN:** Niños, Carlos estudió durante cuarenta minutos.

**LITA:** Díganme, ¿estudio durante media hora o más?

**CHORUS:** More.

**RAYMOND:** Yes, more than a half-hour. Because a half-hour has thirty minutes.

**LITA:** A gardner took thirty minutes to water the garden.

**RAYMOND:** The gardner took a half-hour, or less?

**CHORUS:** A half-hour.

**LITA:** Yes, a half-hour. Because a half-hour has thirty minutes.

**MUSIC:** TRANSITION TO ORAL SEGMENT

**LITA:** *(enthusiastically)* Children, now we're going to do oral addition exercises.

**RAYMOND:** Get ready to answer out loud all together.

**LITA:** Let's start. How much is forty plus eight?

**CHORUS:** Forty-eight.

**RAYMOND:** Forty-eight.

**LITA:** And, sixty plus three?

**CHORUS:** Sixty-three.

**RAYMOND:** Sixty-three.

**LITA:** And, ninety plus two?

**CHORUS:** Ninety-two.

**RAYMOND:** Ninety-two.

**LITA:** And, seventy plus five?

**CHORUS:** Seventy-five.

**RAYMOND:** Seventy-five. Right!

**MUSIC:** TRANSITION TO NOTEBOOKS

**CHORUS:** *(lively)* A la bin, a la bin, a la bin bom ba . . .

**MONSTER:** To the notebooks, to the notebooks.

**ALL:** Let's go now!
*(all laugh)*

**RAYMOND:** Now we're going to solve the exercises in Part One.

**LITA:** Look at the first exercise. Read it.

**CHORUS:** One-third plus one-third.

**RAYMOND:** Tell me, one-third plus one-third is how much?

**CHORUS:** Two-thirds.

**LITA:** Two-thirds.

**RAYMOND:** Good. Right after the equal sign write two-thirds.
*(Music —8 sec.)*

**CORO:** Más.

**RAMÓN:** Sí, más de media hora. Porque media hora tiene treinta minutos.

**LITA:** Un jardinero tardó treinta minutos regando el jardin.

**RAMÓN:** El jardinero tardó, ¿media hora o menos?

**CORO:** Media hora.

**LITA:** Sí, media hora. Porque media hora tiene treinta minutos.

**MÚSICA:** TRANSICIÓN A SEGMENTO ORAL

**LITA:** *(entusiasmada)* Niños, ahora vamos con los ejercicios orales de adición.

**RAMÓN:** Listos a contestar todos juntos y en voz alta.

**LITA:** Empecemos. ¿Cuánto es cuarenta más ocho?

**CORO:** Cuarenta y ocho.

**RAMÓN:** Cuarenta y ocho.

**LITA:** Y, ¿sesenta más tres?

**CORO:** Sesenta y tres.

**RAMÓN:** Sesenta y tres.

**LITA:** Y, ¿noventa más dos?

**CORO:** Noventa y dos.

**RAMÓN:** Noventa y dos.

**LITA:** Y, ¿setenta más cinco?

**CORO:** Setenta y cinco.

**RAMÓN:** Setenta y cinco. ¡Correcto!

**MÚSICA:** TRANSICIÓN A CUADERNOS

**CORO:** *(animado)* A la bín, a la bín, a la bín bom bá . . .

**MONSTRUO:** A los cuadernos, a los cuadernos.

**TODOS:** ¡Vamos ya!
*(ríen)*

**RAMÓN:** Vamos a resolver los ejercicios de la Parte uno.

**LITA:** Miren el primer ejercicio. Léanlo.

**CORO:** Un tercio más un tercio.

**RAMÓN:** Díganme, un tercio más un tercio, ¿cuánto es?

**CORO:** Dos tercios.

**LITA:** Dos tercios.

**RAMÓN:** Bien. Junto al signo igual escriban dos tercios.
*(Música —8 seg.)*

**LITA:** Tell me, did you write two over three?

**CHORUS:** Yes.

**RAYMOND:** Yes, that's the way two-thirds is written. Let's go to the next exercise. Tell me, what are you going to add?

**CHORUS:** Two-fifths plus one-fifth.

**LITA:** Two-fifths plus one-fifth. How much is that?

**CHORUS:** Three-fifths.

**RAYMOND:** Three-fifths. Right after the equal sign write three-fifths.

*(Music —8 sec.)*

**LITA:** Tell me, how did you write it?

**CHORUS:** Three over five.

**RAYMOND:** Three over five. That's the way to write three-fifths.

**LITA:** Look at the next exercise. Read it.

**CHORUS:** Four-tenths plus one-tenth.

**RAYMOND:** Four-tenths plus one-tenth. How much is that?

**CHORUS:** Five-tenths.

**LITA:** Five-tenths. Right after the equal sign write five-tenths.

*(Music —8 sec.)*

**RAYMOND:** How did you write it?

**CHORUS:** Five over ten.

**LITA:** Five over ten. That's how to write five-tenths. Look at the last exercise. Read it.

**CHORUS:** One-fourth plus two-fourths.

**RAYMOND:** One-fourth plus two-fourths. How much is that?

**CHORUS:** Three-fourths.

**RAYMOND:** Three-fourths. Write it.

*(Music —8 sec.)*

**LITA:** How did you write it?

**CHORUS:** Three over four.

**RAYMOND:** Three over four. That's the way to write three-fourths.

**MONSTER:** *(singing)* Fractions, fractions, fractions, easy to write.

*(Everybody laughs)*

**RAYMOND:** Children, don't touch your notebooks now because you are going to listen to a joke.

**MUSIC:** TRANSITION TO A JOKE

**LITA:** Díganme, ¿escribieron dos sobre tres?

**CORO:** Sí.

**RAMÓN:** Sí, así se escribe dos tercios. Vamos al siguiente ejercicio. Díganme, ¿qué van a sumar?

**CORO:** Dos quintos más un quinto.

**LITA:** Y dos quintos más un quinto. ¿Cuánto es?

**CORO:** Tres quintos.

**RAMÓN:** Tres quintos. Junto al signo igual escriban tres quintos.

*(Música —8 seg.)*

**LITA:** Díganme, ¿cómo lo escribieron?

**CORO:** Tres sobre cinco.

**RAMÓN:** Tres sobre cinco. Así se escribe tres quintos.

**LITA:** Miren el siguiente ejercicio. Léanlo.

**CORO:** Cuatro décimos más un décimo.

**RAMÓN:** Cuatro décimos más un décimo. ¿Cuánto es?

**CORO:** Cinco décimos.

**LITA:** Cinco décimos. Junto al signo igual escriban cinco décimos.

*(Música —8 seg.)*

**RAMÓN:** ¿Cómo lo escribieron?

**CORO:** Cinco sobre diez.

**LITA:** Cinco sobre diez. Así se escribe cinco décimos. Miren el último ejercicio. Léanlo.

**CORO:** Un cuarto más dos cuatos.

**RAMÓN:** Y un cuarto más dos cuartos. ¿Cuánto es?

**CORO:** Tres cuartos.

**RAMÓN:** Tres cuartos. Escríbanlo.

*(Música —8 seg.)*

**LITA:** ¿Cómo lo escribieron?

**CORO:** Tres sobre cuatro.

**RAMÓN:** Tres sobre cuatro. Así se escribe tres cuartos.

**MONSTRUO:** *(canta)* Fracciones, fracciones, fracciones. Fáciles para escribir.

*(Todos ríen)*

**RAMÓN:** Niños, dejen sus cuadernos porque van a escuchar un chiste.

**MÚSICA:** TRANSICIÓN A CHISTE

**VOICE:** The mother and the child are talking.

**CHILD:** Mommy, mommy, give me a dime.

**MOTHER:** Another one? But . . . what did you do with the one I gave you this morning?

**CHILD:** Well, I gave it to an old man.

**MOTHER:** I'm glad you're so generous. Here, you can have another dime. But listen, you're not going to give this dime to the old man, are you?

**CHILD:** Of course I will mommy, because he's the one who sells candy.

*(Everybody laughs)*

**MONSTER:** That's awful.

**MUSIC:** TRANSITION TO ORAL SEGMENT

**CHORUS:** Let's go on working.

**RAYMOND:** Children, listen to the subtraction exercises and think of the answer.

**MONSTER:** Answer when you are asked.

**RAYMOND:** Let's begin. Think of twelve minus four.

*(Music — 5 sec.)*

**LITA:** How much is it?

**CHORUS:** Eight.

**RAYMOND:** Eight. Twelve minus four . . . eight.

**LITA:** Let's go on. Think of seventeen minus eight.

*(Music — 5 sec.)*

**RAYMOND:** How much is it?

**CHORUS:** Nine.

**LITA:** Nine. Seventeen minus eight . . . nine.

**RAYMOND:** Think of eleven minus five.

*(Music — 5 sec.)*

**LITA:** How much is it?

**CHORUS:** Six.

**RAYMOND:** Six. Eleven minus five . . . six.

**LITA:** And to finish up, think of fifteen minus eight.

*(Music — 5 sec.)*

**RAYMOND:** How much is it?

**CHORUS:** Seven.

**VOZ:** Conversan la mamá y el niño.

**NIÑO:** Mami, mami, dame un córdoba.

**MAMÁ:** ¿Ah? ¿Otro? Pero . . . ¿qué has hecho con el que te di esta mañana?

**NIÑO:** Es que se lo di a un viejito.

**MAMÁ:** Ah, así me gusta, hijito, que seas caritativo. Toma, pues, este otro córdoba. Pero a ver dime no le vas a dar este otro peso a viejito, ¿verdad?

**NIÑO:** Como no, mami, porque él es el que vende los caramelos.

*(Todos ríen)*

**MONSTRUO:** Así quién no.

**MÚSICA:** TRANSICIÓN A SEGMENTO ORAL

**CORO:** Sigamos trabajando.

**RAMÓN:** Niños, escuchen los ejercicios de sustracción y piensen en la respuesta.

**MONSTRUO:** Contesten cuando se les pregunte.

**RAMÓN:** Empecemos. Piensen en doce menos cuatro.

*(Música — 5 seg.)*

**LITA:** ¿Cuánto es?

**CORO:** Ocho.

**RAMÓN:** Ocho. Doce menos cuatro . . . ocho.

**LITA:** Sigamos. Piénsen en diecisiente menos ocho.

*(Música — 5 seg.)*

**RAMÓN:** ¿Cuánto es?

**CORO:** Nueve.

**LITA:** Nueve. Diecisiente menos ocho . . . nueve.

**RAMÓN:** Piensen en once menos cinco.

*(Música — 5 seg.)*

**LITA:** ¿Cuánto es?

**CORO:** Seis.

**RAMÓN:** Seis. Once menos cinco . . . seis.

**LITA:** Y para terminar, piensen en quince menos ocho.

*(Música — 5 seg.)*

**RAMÓN:** ¿Cuánto es?

**CORO:** Siete.

**LITA:** Seven. Fifteen minus eight . . . seven.

**MUSIC:** TRANSITION TO NOTEBOOKS

**LITA:** Children, let's work in the notebooks now.

**RAYMOND:** We're going to do the exercises in Part Two.

**LITA:** Look carefully. The first exercise—what sign does it have?

**CHORUS:** Plus.

**RAYMOND:** Plus. So what are you going to do?

**CHORUS:** Add.

**LITA:** Yes, you are going to add; add forty-five plus twenty-seven.

**RAYMOND:** Let's begin. In the first column, what are you going to add?

**CHORUS:** Five plus seven.

**RAYMOND:** And five plus seven is how much?

**CHORUS:** Twelve.

**LITA:** Twelve. So are you going to carry?

**CHORUS:** Yes.

**RAYMOND:** Of course, we have to carry. Tell me, below the seven, what are you going to write?

**CHORUS:** Two.

**LITA:** Two. And above the four, what are you going to write?

**CHORUS:** One.

**RAYMOND:** One. Write them.

*(Music —6 sec.)*

**LITA:** In the other column you have one plus four plus two.

**RAYMOND:** Think how much that is and write the answer.

*(Music —8 sec.)*

**LITA:** Look at the answer. Read it.

**CHORUS:** Seventy-two.

**RAYMOND:** Seventy-two.

**LITA:** Let's go on with the other exercise. What sign does it have?

**CHORUS:** Minus.

**RAYMOND:** Minus. So what are you going to do?

**CHORUS:** Subtract.

**LITA:** Subtract. You're going to subtract: fifty-two minus seventeen.

**RAYMOND:** Let's begin. In the first column, look carefully at the two and the seven. Think if you need to borrow.

**LITA:** Siete. Quince menos ocho . . . siete.

**MUSICA:** TRANSICIÓN A CUADERNOS

**LITA:** Niños, continuemos trabajando en los cuadernos.

**RAMÓN:** Vamos a resolver los ejercicios de la Parte dos.

**LITA:** Fíjense bien. El primer ejercicio, ¿qué signo tiene?

**CORO:** Más.

**RAMÓN:** Más. Entonces, ¿qué van a hacer?

**CORO:** A sumar.

**LITA:** Sí, van a sumar; a sumar cuarenta y cinco más veintisiete.

**RAMÓN:** Empecemos. En la primera columna, ¿qué van a sumar?

**CORO:** Cinco más siete.

**RAMÓN:** Y cinco más siete ¿cuánto es?

**CORO:** Doce.

**LITA:** Doce. Entonces, ¿van a llevar?

**CORO:** Sí.

**RAMÓN:** Claro, hay que llevar. Díganme, debajo del siete ¿qué van a escribir?

**CORO:** El dos.

**LITA:** El dos. Y arriba del cuatro ¿qué van a escribir?

**CORO:** El uno.

**RAMÓN:** El uno. Escríbanlos.

*(Música —6 seg.)*

**LITA:** En la otra columna tienen uno más cuatro más dos.

**RAMÓN:** Piensen cuánto es y escriban la respuesta.

*(Música —8 seg.)*

**LITA:** Miren la respuesta. Léanla.

**CORO:** Setenta y dos.

**RAMÓN:** Setenta y dos.

**LITA:** Sigamos con el otro ejercicio. ¿Qué signo tiene?

**CORO:** Menos.

**RAMÓN:** Menos. Entonces, ¿qué van a hacer?

**CORO:** A restar.

**LITA:** A restar. Van a restar cincuenta y dos menos diecisiete.

**RAMÓN:** Empecemos. En la primera columna, fíjense en el dos y en el siete. Piensen si hay que prestar.

*(Pause —3 sec.)*

**LITA:** Are you going to borrow?

**CHORUS:** Yes.

**RAYMOND:** Yes, you are going to because the bigger number is on the bottom.

**LITA:** Okay, do the borrowing, just the borrowing.

*(Music —8 sec.)*

**RAYMOND:** Now you have twelve minus seven. And twelve minus seven is how much?

**CHORUS:** Five.

**LITA:** Five. Write it below the seven.

*(Pause —3 sec.)*

**RAYMOND:** Finish this exercise.

*(Music —8 sec.)*

**LITA:** In this exercise, how much did you get?

**CHORUS:** Thirty-five.

**RAYMOND:** Thirty-five. Right.

**LITA:** Look at the next exercise. What sign does it have?

**CHORUS:** Plus.

**RAYMOND:** Plus. So what are you going to do?

**CHORUS:** Add.

**LITA:** Add. You're going to add: seventy-six plus nineteen. You can do this one by yourselves. Go ahead.

*(Music —15 sec.)*

**RAYMOND:** Children, tell me, did you carry?

**CHORUS:** Yes.

**LITA:** Yes, you carried. Read the whole answer.

**CHORUS:** Ninety-five.

**RAYMOND:** Ninety-five. Very good.

**LITA:** Let's go on to the last exercise. Tell me, what sign does it have?

**CHORUS:** Minus.

**RAYMOND:** Minus. So what are you going to do?

**CHORUS:** Subtract.

**LITA:** Yes, subtract. You are going to subtract: eighty-two minus forty-five. Do this exercise.

*(Pausa —3 seg.)*

**LITA:** ¿Van a prestar?

**CORO:** Sí.

**RAMÓN:** Sí, van a prestar porque el mayor está abajo.

**LITA:** Entonces, presten, sólo presten.

*(Música —8 seg.)*

**RAMÓN:** Ahora, tienen doce menos siete. Y doce menos siete, ¿cuánto es?

**CORO:** Cinco.

**LITA:** Cinco. Escríbanlo debajo del siete.

*(Pausa —3 seg.)*

**RAMÓN:** Terminen de resolver ese ejercicio.

*(Música —8 seg.)*

**LITA:** Ese ejercicio, ¿cuánto les dio?

**CORO:** Treinta y cinco.

**RAMÓN:** Treinta y cinco. Correcto.

**LITA:** Miren el siguiente ejercicio, ¿qué signo tiene?

**CORO:** Más.

**RAMÓN:** Más. Entonces, ¿qué van a hacer?

**CORO:** A sumar.

**LITA:** A sumar. A sumar setenta y seis más diecinueve. Ustedes pueden resolverlo solos. Háganlo.

*(Música —15 seg.)*

**RAMÓN:** Niños, díganme, ¿llevaron?

**CORO:** Sí.

**LITA:** Sí, llevaron. Lean toda la respuesta.

**CORO:** Noventa y cinco.

**RAMÓN:** Noventa y cinco. Muy bien.

**LITA:** Pasemos al último ejercicio. Díganme, ¿qué signo tiene?

**CORO:** Menos.

**RAMÓN:** Menos. Entonces, ¿qué van a hacer?

**CORO:** A restar.

**LITA:** Sí, a restar. Van a restar ochenta y dos menos cuarenta y cinco. Resuelvan ese ejercicio.

*(Music — 15 sec.)*

**RAYMOND:** Children, did you borrow?

**CHORUS:** Yes.

**LITA:** Of course. Read the answer.

**CHORUS:** Thirty-seven.

**RAYMOND:** Thirty-seven. Right.

**LITA:** Very good. Now leave your notebooks and pencils alone on the table because . . .

**MONSTER:** Ladies and gentlemen . . .

**CHORUS:** The time to play has come.

**MUSIC:** TRANSITION TO GAME

**RAYMOND:** Today we are going to play "What the king commands."

**MUSIC:** THE ACUARTILLADO (SANTO DOMINGO)

**RAYMOND:** Let's begin. What the king commands . . .

**CHORUS:** The mayor signs.

**RAYMOND:** The king has commanded that everyone play the guitar. Let's go play the guitar.

**SOUND:** GUITAR
*(Studio) (5 sec.)*

Stop. What the king commands . . .

**CHORUS:** The mayor signs.

**RAYMOND:** The king has commanded that everyone play the drum. Let's go play the drum.

**SOUND:** DRUM
*(Studio) (5 sec.)*

Stop. What the king commands . . .

**CHORUS:** The mayor signs.

**RAYMOND:** The king has commanded that everyone play the marimba. Play the marimba.

**SOUND:** MARIMBA
*(Studio) (5 sec.)*

Stop, stop. What the king commands . . .

**CHORUS:** The mayor signs.

**RAYMOND:** The king has commanded that everyone play the trumpet. Let's go play the trumpet.

**SOUND:** TRUMPET
*(Studio) (5 sec.)*

*(Música — 15 seg.)*

**RAMÓN:** Niños, ¿prestaron?

**CORO:** Sí.

**LITA:** Claro que sí. Lean la respuesta.

**CORO:** Treinta y siete.

**RAMÓN:** Treinta y siete. Correcto.

**LITA:** Bien. Ahora, dejen sus cuadernos y lápices sobre la mesa porque . . .

**MONSTRUO:** Señores y señoras . . .

**CORO:** De jugar llegó la hora.

**MÚSICA:** TRANSICIÓN A JUEGO

**RAMÓN:** Hoy vamos a jugar "Lo que manda el rey."

**MÚSICA:** EL ACUARTILLADO (SANTO DOMINGO)

**RAMÓN:** Empecemos. Lo que manda el rey . . .

**CORO:** Lo firma el alcalde.

**RAMÓN:** El rey ha mandado que todo el mundo toque la guitarra. Vamos, toquen la guitarra.

**SONIDO:** GUITARRA
*(Estudio) (5 seg.)*

Paren. Lo que manda el rey . . .

**CORO:** Lo firma el alcalde.

**RAMÓN:** El rey ha mandado que todos toquen tambor. Vamos, toquen tambor.

**SONIDO:** TAMBOR
*(Estudio) (5 seg.)*

Paren. Lo que manda el rey . . .

**CORO:** Lo firma el alcalde.

**RAMÓN:** El rey ha mandado que todos toquen la marimba. A tocar marimba.

**SONIDO:** MARIMBA
*(Estudio) (5 seg.)*

Paren, paren. Lo que manda el rey . . .

**CORO:** Lo firma el alcalde.

**RAMÓN:** El rey ha mandado que todo mundo toque trompeta. Vamos, a tocar trompeta.

**SONIDO:** TROMPETA
*(Estudio) (5 seg.)*

Stop, stop. That's all.

**MUSIC:** TRANSITION TO CHALKBOARD

**CHORUS:** To the chalkboard, board, board, board.

**LITA:** Children, let's work some more now. Look at Part Three on the chalkboard.

**RAYMOND:** Look carefully at line "A." There are some numbers there.

**LITA:** Look at the first number. Tell me, how do you read it?

**CHORUS:** Two hundred fifty-eight.

**RAYMOND:** Two hundred fifty-eight. Look at the second number. How do you read it?

**CHORUS:** Five hundred eighty-two.

**LITA:** Five hundred eighty-two. And the last one?

**CHORUS:** Eight hundred twenty-five.

**RAYMOND:** Eight hundred twenty-five.

**LITA:** Look carefully at those numbers and think which one is the greatest.

*(Music — 5 sec.)*

Which one?

**CHORUS:** Eight hundred twenty-five.

**RAYMOND:** Eight hundred twenty-five is the greatest.

**LITA:** Let's go on to line "B." Look at the first number. How do you read it?

**CHORUS:** Seven hundred six.

**RAYMOND:** Seven hundred six. And the next one, how do you read it?

**CHORUS:** Six hundred seventy.

**LITA:** Six hundred seventy. And the last number, how do you read it?

**CHORUS:** Six hundred seven.

**LITA:** Six hundred seven. Look carefully at those numbers and think which one is the greatest.

*(Music — 5 sec.)*

Which one?

**CHORUS:** Seven hundred six.

**RAYMOND:** Seven hundred six is the greatest.

**LITA:** Let's go to line "C." Look at the first number, how do you read it?

Alto, alto. Terminamos.

**MÚSICA:** TRANSICIÓN AL PIZARRÓN

**CORO:** Al pizarrón, rón, rón, rón.

**LITA:** Niños, sígamos trabajando. Miren al pizarrón a la Parte tres.

**RAMÓN:** Fíjense en la fila "A." Ahí hay unos números.

**LITA:** Díganme, el primer número, ¿cómo se lee?

**CORO:** Doscientos cincuenta y ocho.

**RAMÓN:** Doscientos cincunta y ocho. Miren al segundo número, ¿cómo se lee?

**CORO:** Quinientos ochenta y dos.

**LITA:** Quinientos ochenta y dos. ¿Y el último?

**CORO:** Ochocientos veinticinco.

**RAMÓN:** Ochocientos veinticinco.

**LITA:** Fíjense bien en esos números y piensen cuál de ellos es mayor.

*(Música — 5 seg.)*

¿Cuál?

**CORO:** Ochocientos veinticinco.

**RAMÓN:** Ochocientos veinticinco es mayor.

**LITA:** Pasemos a la fila "B." Miren el primer número, ¿cómo se lee?

**CORO:** Setecientos seis.

**RAMÓN:** Setecientos seis. Y el que sigue, ¿cómo se lee?

**CORO:** Seiscientos setenta.

**LITA:** Seiscientos setenta. Y el último número, ¿cómo se lee?

**CORO:** Seiscientos siete.

**LITA:** Seiscientos siete. Fíjense bien en esos números y piensen cuál es mayor.

*(Música — 5 seg.)*

¿Cuál?

**CORO:** Setecientos seis.

**RAMÓN:** Setecientos seis es mayor.

**LITA:** Vamos a la fila "C." El primer número, ¿cómo se lee?

**CHORUS:** Three hundred forty-one.

**RAYMOND:** Three hundred forty-one. And the next one, how do you read it?

**CHORUS:** Four hundred thirteen.

**LITA:** Four hundred thirteen. And the last one?

**CHORUS:** One hundred thirty-four.

**LITA:** One hundred thirty-four. Now think which one of those numbers is the greatest.

*(Music — 5 sec.)*

Which one?

**CHORUS:** Four hundred thirteen.

**RAYMOND:** Four hundred thirteen is the greatest.

**MUSIC:** TRANSITION TO NOTEBOOKS

**LITA:** Children, open your notebooks again.

**RAYMOND:** Look for a clean place to use because you are going to draw some marbles.

**LITA:** Yes, you are going to draw some marbles to solve some division problems.

**RAYMOND:** First you are going to do thirteen divided by five.

**LITA:** Tell me, how many marbles are you going to draw?

**CHORUS:** Thirteen.

**RAYMOND:** Thirteen. Draw them.

*(Music — 12 sec.)*

**LITA:** Since the exercise is thirteen divided by five, circle five marbles.

*(Music —8 sec.)*

**RAYMOND:** Circle another five.

*(Music —8 sec.)*

**LITA:** Tell me, how many marbles were left not circled?

**CHORUS:** Three.

**RAYMOND:** Three. Now tell me, how many groups did you make?

**CHORUS:** Two.

**LITA:** Two. Look carefully at the drawing.

**RAYMOND:** Tell me, how much is thirteen divided by five?

**CHORUS:** Two and three left over.

**LITA:** Two and three left over.

**CORO:** Trescientos cuarenta y uno.

**RAMÓN:** Trescientos cuarenta y uno. Y el siguiente ¿cómo se lee?

**CORO:** Cuatrocientos trece.

**LITA:** Cuatrocientos trece. ¿Y el último?

**CORO:** Ciento treinta y cuatro.

**LITA:** Ciento treinta y cuatro. Bien. Piensen cuál de esos números es mayor.

*(Música — 5 seg.)*

¿Cuál?

**CORO:** Cuatrocientos trece.

**RAMÓN:** Cuatrocientos trece es mayor.

**MÚSICA:** TRANSICIÓN A CUADERNOS

**LITA:** Niños, abran sus cuadernos otra vez.

**RAMÓN:** Busquen una parte desocupada porque van a dibujar unas bolitas.

**LITA:** Sí, van a dibujar bolitas para resolver unas divisiones.

**RAMÓN:** Primero van a resolver trece entre cinco.

**LITA:** Díganme, ¿cuántas bolitas van a dibujar?

**CORO:** Trece.

**RAMÓN:** Trece. Dibújenlas.

*(Música — 12 seg.)*

**LITA:** Como el ejercicio es trece entre cinco, encierren en un círculo cinco bolitas.

*(Música — 8 seg.)*

**RAMÓN:** Encierren otras cinco.

*(Música — 8 seg.)*

**LITA:** Díganme, ¿cuántas bolitas quedaron sin encerrar?

**CORO:** Tres.

**RAMÓN:** Tres. Ahora, díganme, ¿cuántos grupos formaron?

**CORO:** Dos.

**LITA:** Dos. Fíjense bien en el dibujo.

**RAMÓN:** Díganme, ¿cuánto es trece entre cinco?

**CORO:** Dos y sobran tres.

**LITA:** Dos y sobran tres.

**RAYMOND:** Let's do this other exercise. Fifteen divided by five.

**LITA:** Tell me, how many marbles are you going to draw?

**CHORUS:** Fifteen.

**RAYMOND:** Fifteen. Draw them.

*(Music — 15 sec.)*

**LITA:** Since the exercise is fifteen divided by five, how many marbles are you going to circle in each group?

**CHORUS:** Five.

**RAYMOND:** Five. Make groups of five.

*(Music — 15 sec.)*

**LITA:** How many groups did you make?

**CHORUS:** Three.

**RAYMOND:** Three. Look at the drawing.

**LITA:** Tell me, how much is fifteen divided by five?

**CHORUS:** Three and zero left over.

**RAYMOND:** Three and zero left over.

**LITA:** Let's go on to another exercise. This one is ten divided by three.

**RAYMOND:** How many marbles are you going to draw?

**CHORUS:** Ten.

**LITA:** Ten. Draw them.

*(Music — 15 sec.)*

**RAYMOND:** Since the exercise is ten divided by three, how many marbles are you going to circle in each group?

**CHORUS:** Three.

**LITA:** Three. Make groups of three.

*(Music — 12 sec.)*

**RAYMOND:** How many groups did you make?

**CHORUS:** Three.

**LITA:** Three. Look at the drawing.

**RAYMOND:** Tell me, how much is ten divided by three?

**CHORUS:** Three and one left over.

**LITA:** Three and one left over.

**MUSIC:** TRANSITION TO RIDDLE

**MONSTER:** Guess, guessers.

**CHORUS:** And listen, listeners.

**RAMÓN:** Hágamos este otro ejercicio. Quince entre cinco.

**LITA:** Díganme, ¿cuántas bolitas van a dibujar?

**CORO:** Quince.

**RAMÓN:** Quince. Dibújenlas.

*(Música — 15 seg.)*

**LITA:** Como el ejercicio es quince entre cinco, ¿cuántas bolitas van a encerrar en cada grupo?

**CORO:** Cinco.

**RAMÓN:** Cinco. Hagan grupos de cinco.

*(Música — 15 seg.)*

**LITA:** ¿Cuántos grupos formaron?

**CORO:** Tres.

**RAMÓN:** Tres. Fíjense en el dibujo.

**LITA:** Díganme, ¿cuánto es quince entre cinco?

**CORO:** Tres y sobra cero.

**RAMÓN:** Tres y sobra cero.

**LITA:** Pasemos a otro ejercicio. Es diez entre tres.

**RAMÓN:** ¿Cuántas bolitas van a dibujar?

**CORO:** Diez.

**LITA:** Diez. Dibújenlas.

*(Música — 15 seg.)*

**RAMÓN:** Como el ejercicio es diez entre tres, ¿cuántas bolitas van a encerrar en cada grupo?

**CORO:** Tres.

**LITA:** Tres. Hagan grupos de tres.

*(Música — 12 seg.)*

**RAMÓN:** ¿Cuántos grupos formaron?

**CORO:** Tres.

**LITA:** Tres. Miren el dibujo.

**RAMÓN:** Díganme, ¿cuánto es diez entre tres?

**CORO:** Tres y sobra uno.

**LITA:** Tres y sobra uno.

**MÚSICA:** TRANSICIÓN A ADIVINANZA.

**MONSTRUO:** Adivinen, adivinadores.

**CORO:** Y escuchen, escuchadores.

**LITA:** Here is the riddle for today.

**MONSTER:** Pay attention.

**RAYMOND:** This fat man that always says: tan, tan.
He calls people to church,
He calls people to war,
He wins battles on the ground
And in the brave heart.
Listen to him!

**SOUND:** DRUM
*(1024, A - 2) (10 sec.)*

Tell me, what is it?

**CHORUS:** It's the drum, the drum.

**MUSIC:** TRANSITION TO ORAL SEGMENT

*Mix to*

**SOUND:** TRUMPET
*(1015, A - 7)*

**MONSTER:** Friends, something is happening over there. What can it be?

**LITTLE GIRL:** Come on, let's go see what's happening.

**ALL:** Let's go.

**EFFECT:** HARP

*Mix to*

**SOUND:** VOICES
*(1018, B - 17) (Fade in and under)*

**LITTLE GIRL:** Ah! It's the stadium.

**LITTLE BOY:** Yes, they said there'd be some races today.

**MONSTER:** Let's go closer to see the motorcycle races.

**LITA:** Children, listen quietly to see how many riders stay in the race.

**SOUND:** MOTORCYCLE
*(1020, B - 12) (5 sec.) (Fade under)*

**ANNOUNCER:** Welcome to today's races, folks. The motorcycle riders are ready. In a few moments we'll begin. On the track, right now, there are forty-two contestants and—there they go!

**LITA:** Aquí está la adivinanza de hoy.

**MONSTRUO:** Pongan atención.

**RAMÓN:** Este señor gordiflón que siempre dice: ton, ton.
Llama a la iglesia,
Llama a la guerra.
Gana batallas en tierra.
Y en el bravo corazón.
¡Escúchenlo con atención!

**SONIDO:** TAMBOR
*(1024, A - 2) (10 seg.)*
Díganme, ¿qué es?

**CORO:** Es el tambor, el tambor.

**MÚSICA:** TRANSICIÓN A SEGMENTO ORAL
*Sigue*

**SONIDO:** TROMPETA
*(1015, A - 7)*

**MONSTRUO:** Amigos, algo sucede allá. ¿Qué será?

**NIÑA:** Van, vamos a asomarnos para ver que ocurre.

**TODOS:** ¡Vamos!

**EFECTO:** ARPA
*Sigue*

**SONIDO:** VOCES
*(1018, B - 17) (Entra y queda)*

**NIÑA:** ¡Ah! Es el centro deportivo.

**NIÑO:** Sí, para hoy anunciaron las competéncias.

**MONSTRUO:** Acerquémonos para ver las carreras de motos.

**LITA:** Niños, escuchen calladitos para que sepan cuántos motociclistas quedan en la carrera.

**SONIDO:** MOTOS
*(1020, B - 12) (5 seg.) (Sale)*

**LOCUTOR:** Bienvenidos a las competéncias de hoy. Los motociclistas están preparados. Dentro de pocos minutos empezaremos. En la pista hay cuarenta y dos competidores. ¡Allá van!

**SOUND:** REPEATS
*(Keep under)*

**GEORGE:** There are sure a lot of riders in the race today!

**LUIS:** Yeah. Imagine! Forty-two!

**SOUND:** *Fade up and under*

**GEORGE:** *(startled)* Look! Two riders have fallen!

**LITA:** Children, tell me, how many motorcycles are still in the race?

**CHORUS:** Forty.

**RAYMOND:** Yes, forty.

**SOUND:** HARP

**ANNOUNCER:** And now we are going to the last race of the day. The runners are getting ready. They're ready! They're off!

**SOUND:** PEOPLE RUNNING
*(Studio)*
*Mix to*

**SOUND:** MURMUR
*(1021, A - 17) (Fade in and out)*

**LITTLE GIRL:** Look, there are fifty-six runners!

**LITTLE BOY:** Ah, they're off!

**LITTLE GIRL:** Look! Look! Six runners have already finished.

**SOUND:** VOICES
*(Repeat and fade out)*

**LITA:** Children, six runners have finished. How many have not finished yet?

**CHORUS:** Fifty.

**RAYMOND:** Yes, fifty runners.

**MUSIC:** TRANSITION TO NOTEBOOKS
*Mix to*

**MUSIC:** MULTIPLICATION
*(Recorded)*

Look carefully, listen carefully,
How nicely it's done.
To multiply, to multiply,
And in a short time,

**SONIDO:** REPITE
*(Queda a fondo)*

**JORGE:** ¡Van muchos motociclistas en la carrera de hoy!

**LUIS:** Fíjate, son cuarenta y dos.

**SONIDO:** *Sube y sale*

**JORGE:** *(sorprendido)* ¡Mira! Dos motociclistas han caido.

**LITA:** Niños, díganme, ¿cuántos motociclistas quedan en la carrera?

**CORO:** Cuarenta.

**RAMÓN:** Sí, cuarenta.

**SONIDO:** ARPA

**LOCUTOR:** Y ahora vamos a la última competéncia del día. Los corredores se preparan. ¡Listos! ¡Salen!

**SONIDO:** PASOS CORRIENDO
*(Estudio)*
*Mezcaldo con*

**SONIDO:** MURMULLO
*(1021, A - 17) (Entra y sale)*

**NIÑA:** Mira, ¡son cincuenta y seis corredores!

**NIÑO:** Allá van todos juntos.

**NIÑA:** ¡Mira, mira! Ya llegaron seis corredores.

**SONIDO:** VOCES
*(Repite y sale)*

**LITA:** Niños, llegaron seis corredores, ¿cuántos faltan por llegar?

**CORO:** Cincuenta.

**RAMÓN:** Sí, cincuenta corredores.

**MÚSICA:** TRANSICIÓN A CUADERNOS
*Sigue*

**MÚSICA:** LA MULTIPLICACIÓN
*(Grabada)*

Miren bien, escuchen bien,
Que bonito se hace.
A multiplicar, a multiplicar.
Y durante un rato.

One times two is two,
Two times two is four,
Three times two is six,
Four times two is eight.

**RAYMOND:** Children, let's go on working in the notebooks. We're going to dictate some multiplication exercises.

**LITA:** But you're not going to solve them yet. You're just going to write them. Let's begin.

**RAYMOND:** You're going to write the exercise one hundred sixty-eight times four like this:
First, write the number one hundred sixty-eight.

*(Music — 9 sec.)*

Below the eight, write the four.

*(Pause — 3 sec.)*

A little to the outside write the multiplication sign.

*(Pause — 2 sec.)*

And draw the line underneath.

*(Pause — 2 sec.)*

**LITA:** Write this other exercise. Always writing from top to bottom, write one hundred sixty-nine times three. I'll repeat it. One hundred sixty-nine times three. Write it.

*(Music — 16 sec.)*

**RAYMOND:** Let's go on to another. Write four hundred six times two. Four hundred six times two.

*(Music — 16 sec.)*

**LITA:** Now, the last one. Write one hundred fifty-three times five. One hundred fifty-three times five.

*(Music — 16 sec.)*

**RAYMOND:** Quietly, do these exercises by yourselves.

**LITA:** Yes, children, because we're going now.

**MUSIC:** THEME
*(Fade in)*

**CHORUS:** Bye, little friends.

**LITA:** See you soon.

**RAYMOND:** Behave yourselves.

**ANNOUNCER:** We have presented Lesson 171. The following lesson will be 172.

Uno por dos igual a dos,
Dos por dos es cuatro,
Tres por dos igual a seis,
Cuatro por does es ocho.

**RAMÓN:** Niños, sigamos en los cuadernos. Vamos a dictarles unos ejercicios de multiplicación.

**LITA:** Pero no los van a resolver todavía, sólo van a escribirlos. Empecemos.

**RAMÓN:** Van a escribir el ejercicio ciento sesenta y ocho por cuatro, así:

Primero escriban el numero ciento sesenta y ocho.

*(Música — 9 seg.)*

Debajo del ocho, escriban el cuatro.

*(Pausa — 3 seg.)*

Un poco afuera escriban el signo por.

*(Pausa — 2 seg.)*

Y pasen la raya debajo.

*(Pausa — 2 seg.)*

**LITA:** Escriban este otro ejercicio. Siempre de arriba hacia abajo, escriban ciento sesenta y nueve por tres. Repito. Ciento sesenta y nueve por tres. Escríbanlo.

*(Música — 16 seg.)*

**RAMÓN:** Sigamos. Escriban cuatrocientos seis por dos. Cuatrocientos seis por dos.

*(Música — 16 seg.)*

**LITA:** Por último, escriban ciento cincuenta y tres por cinco. Ciento cincuenta y tres por cinco.

*(Música — 16 seg.)*

**RAMÓN:** Calladitos, ustedes solos resuelvan esos ejercicios.

**LITA:** Sí, niños, porque nosotros nos vamos.

**MÚSICA:** TEMA

*(Entra)*

**CORO:** Adiós, amiguitos.

**LITA:** Hasta pronto.

**RAMÓN:** Pórtense bien.

**LOCUTOR:** Hemos presentado la lección ciento setenta y uno. La siguiente lección será la ciento setenta y dos.

## SECOND GRADE
## TEACHER'S GUIDE
## LESSON 171

### BEFORE THE BROADCAST

(a) Copy on the chalkboard the following groups of exercises (Part One and Part Two) and tell the children to copy them.

Part One

1/3 + 1/3 = ___ 2/5 + 1/5 = ___
4/10 + 1/10 = ___ 1/4 + 2/4 = ___

Part Two

| | | | |
|---|---|---|---|
| 45 | 52 | 76 | 82 |
| +27 | −17 | −19 | −45 |

(b) Copy on the chalkboard Part Three, but tell the children not to copy the exercises.

Part Three

| | | | |
|---|---|---|---|
| A) | 258 | 582 | 825 |
| B) | 706 | 670 | 607 |
| C) | 341 | 413 | 134 |

### AFTER T[illegible]BROADCAST

(a) *Verti[illegible]tiplication by dictation.* When the broadcast has ended, let the childr[illegible] solve the multiplication exercises that were dictated by radio. Observe them as they work. If some children have difficulty, let them consult their multiplication tables to help them find the answers.

## SEGUNDO GRADO
## GUÍA DE LA LECCIÓN 171

### ANTES DE LA TRANSMISIÓN

(a) Copie en el pizarrón los siguientes grupos de ejercicios, (Partes uno y dos) y que los niños los copien también.

Parte uno

1/3 + 1/3 = ___ 2/5 + 1/5 = ___
4/10 + 1/10 = ___ 1/4 + 2/4 = ___

Parte dos

$$\begin{array}{r} 45 \\ +27 \\ \hline \end{array} \quad \begin{array}{r} 52 \\ -17 \\ \hline \end{array} \quad \begin{array}{r} 76 \\ -19 \\ \hline \end{array} \quad \begin{array}{r} 82 \\ -45 \\ \hline \end{array}$$

(b) Copie en el pizarrón la Parte tres pero que los niños no la copien.

Parte tres

A) 258 582 825
B) 706 670 607
C) 341 413 134

### DESPUES DE LA TRANSMISIÓN

(a) *Multiplicación vertical al dictado.* Finalizada la transmisión deje que los niños resuelvan los ejercicios de multiplicación que les dictó la radio. Obsérvelos mientras trabajan. Si alguno tiene dificultad permítales que consulten sus tablas para ayudarse a encontrar las respuestas.

When everyone has finished, have several children go to the chalkboard and give them again the exercises to solve. The other children can verify their answers and make corrections where there are mistakes. The exercises that were dictated by the radio are:

$$\begin{array}{rrrr} 168 & 169 & 406 & 153 \\ \times\ \ 4 & \times\ \ 3 & \times\ \ 2 & \times\ \ 5 \\ \hline \end{array}$$

(b) *Vertical subtraction.* Copy on the chalkboard the following exercises:

$$\begin{array}{rrrr} 540 & 945 & 850 & 562 \\ -286 & -757 & -279 & -173 \\ \hline \end{array}$$

Ask the children to copy and solve these exercises. Observe them as they work. If some children have difficulty, tell them to pay attention to the digits that they are going to subtract, and that when the digit below is greater than that above, they can not subtract and must borrow.

When everyone has finished have several of the children solve the exercises on the chalkboard. The other children can check their work and make corrections if necessary.

(c) *Vertical division.* Copy on the chalkboard the following exercises:

95)2 847)4 68)3 465)2

Ask the children to copy and solve these exercises. Give help where necessary to the children having difficulty. Afterwards have several children solve the exercises on the chalkboard so that the others have the opportunity to check their answers. The children who make mistakes may correct them. Check the corrections of these children.

(d) *Writing numbers by dictation.* Dictate to the children the following numbers to write in their notebooks.

5091 3871 2302 6800 9001 4101

Give sufficient time for the children to write every number. After you have dictated all of the numbers, tell the children: "Look at number 5091.

Cuando todos hayan terminado pase a varios al pizarrón y dícteles nuevamente los ejercicios para que los resuelvan. Los demás comprobarán sus respuestas y harán correcciones los niños que se hayan equivocado. Los ejercicios que dictó la radio fueron:

$$\begin{array}{r} 168 \\ \times\ 4 \\ \hline \end{array} \quad \begin{array}{r} 169 \\ \times\ 3 \\ \hline \end{array} \quad \begin{array}{r} 406 \\ \times\ 2 \\ \hline \end{array} \quad \begin{array}{r} 153 \\ \times\ 5 \\ \hline \end{array}$$

(b) *Sustracción vertical.* Copie en el pizarrón los siguientes ejercicios:

$$\begin{array}{r} 540 \\ -286 \\ \hline \end{array} \quad \begin{array}{r} 945 \\ --757 \\ \hline \end{array} \quad \begin{array}{r} 850 \\ -279 \\ \hline \end{array} \quad \begin{array}{r} 562 \\ -173 \\ \hline \end{array}$$

Pida a los niños que copien y resuelvan estos ejercicios. Obsérveles mientras trabajan. Si alguno tiene dificultad dígales que se fijen bien en las cifras que van a restar ya que cuando la cifra de abajo es mayor no se puede restar y entonces tiene que prestar.

Cuando todos hayan terminado pase a varios niños a resolver estos ejercicios al pizarrón. Los demás revisarán sus trabajos y harán las correcciones necesarias.

(c) *División vertical.* Copie en el pizarrón los siguientes ejercicios:

$$95\overline{)2\ } \quad 847\overline{)4\ } \quad 68\overline{)3\ } \quad 465\overline{)2\ }$$

Pida a los niños que copien y resuelvan estos ejercicios. Preste ayuda en caso necesario a los que tengan dificultad. Después pase a varios a resolver estos ejercicios al pizarrón para que los demás tengan la oportunidad de comprobar sus respuestas. Los niños que se hayan equivocado harán correcciones. Revise las correcciones que hacen los niños.

(d) *Escribir números al dictado.* Dicte a los niños los siguientes números para que los escriban en sus cuadernos.

5091 3871 2302 6800 9001 4101

Deles suficiente tiempo para que escriban cada número. Después que haya díctado todos los números diga a los niños: "Vean el número 5091.

What digits did you write? (five, zero, nine, one). Now look at the following numbers, 3871. What digits did you write?" (three, eight, seven, one). Ask the same questions for each number. Have several of the children come to the chalkboard and give them the same numbers to write so the other children have the chance to compare and correct their work. Finally, point with a pointer to each number written on the chalkboard so all the children can read them in a loud voice.

¿Qué cifras escribieron? (cinco, cero, nueve, uno). Ahora, vean el siguiente número, el 3871. ¿Qué cifras escribieron? (tres, ocho, siete, uno). Haga la misma pregunta con los demás números. Pase a continuación a varios niños al pizarrón y dícteles estos números para que los escriban y que los demás tengan oportunidad de comparar y corregir sus trabajos. Finalmente, señale con una regla cada número escrito en la pizarra para que los lean todos los niños en voz alta.

# APPENDIX C

## POSTTEST SCORES FOR EXPERIMENTAL, CONTROL, EXPERIENCED, AND NONEXPERIENCED STUDENTS

### TABLE A

Performance of Experimental and Control Students on 1977 Second-grade Posttest

| Exercise (type)[a] | Item form | Percentage correct |  | Description of exercise |
|---|---|---|---|---|
|  |  | Experimental | Control |  |
| 1(I) | I | 41.0 | 49.1 | Write the number that comes after 349 |
| 1(I) | II | 77.9 | 70.8 | Write the number that comes after 71 |
| 1(I) | III | 52.9 | 63.2 | Write the number that comes after 682 |
| 1(I) | IV | 69.8 | 74.6 | Write the number that comes after 39 |
| 1(I) | V | 66.9 | 70.2 | Write the number that comes after 306 |
| 2(I) | I | 83.9 | 85.5 | Count the beans and write the numeral on the line (25 beans) |
| 2(I) | II | 86.7 | 86.7 | Count the beans and write the numeral on the line (32 beans) |
| 2(I) | III | 96.8 | 93.4 | Count the beans and write the numeral on the line (8 beans) |
| 2(I) | IV | 90.6 | 88.2 | Count the beans and write the numeral on the line (17 beans) |
| 2(I) | V | 82.5 | 76.0 | Count the beans and write the numeral on the line (40 beans) |
| 3(I) | I | 6.2 | 8.2 | Circle the largest number (1/4 1/2 1/3) |
| 3(I) | II | 69.6 | 60.2 | Circle the largest number (923 479 150) |
| 3(I) | III | 83.9 | 77.4 | Circle the largest number (59 73 75) |
| 3(I) | IV | 2.5 | 5.5 | Circle the largest number (1/10 1/5 1/4) |
| 3(I) | V | 48.7 | 44.2 | Circle the largest number (34 401 149) |

(TABLE A, cont.)

| Exercise (type)[a] | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Experimental | Control | |
| 4(G) | I | 88.7 | 89.3 | Circle 7359<br>(3759 9537 7359 7539) |
| 4(G) | II | 95.8 | 93.9 | Circle 690<br>(69 690 960 96) |
| 4(G) | III | 87.3 | 92.6 | Circle 706<br>(706 760 607 76) |
| 4(G) | IV | 95.0 | 97.3 | Circle 74<br>(40 74 47 70) |
| 4(G) | V | 96.4 | 92.1 | Circle 241<br>(142 421 251 241) |
| 5(G) | I | 92.5 | 81.3 | Write 237 |
| 5(G) | II | 55.4 | 33.3 | Write 2989 |
| 5(G) | III | 76.4 | 92.6 | Write 608 |
| 5(G) | IV | 83.5 | 96.4 | Write 71 |
| 5(G) | V | 88.6 | 81.9 | Write 830 |
| 6(G) | I | 66.0 | 57.1 | Circle the 8th soldier |
| 6(G) | II | 97.6 | 93.9 | Circle the 2nd soldier |
| 6(G) | III | 89.2 | 78.7 | Circle the 4th soldier |
| 6(G) | IV | 46.0 | 39.6 | Circle the 10th soldier |
| 6(G) | V | 77.1 | 79.5 | Circle the 6th soldier |
| 7(I) | I | 82.0 | 59.1 | 842<br>+ 41 |
| 7(I) | II | 82.3 | 62.0 | 41<br>+30 |
| 7(I) | III | 82.6 | 68.9 | 3886<br>+5102 |
| 7(I) | IV | 73.0 | 65.5 | 504<br>+132 |
| 7(I) | V | 76.6 | 42.3 | 26<br>+ 3 |
| 8(G) | I | 85.5 | 76.8 | Circle the figure divided in half |
| 8(G) | II | 83.1 | 74.8 | Circle the figure divided in fourths |
| 8(G) | III | 86.6 | 84.0 | Circle the figure divided in fifths |

(TABLE A, cont.)

| Exercise (type)[a] | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Experimental | Control | |
| 8(G) | IV | 65.5 | 51.4 | Circle the figure divided in tenths |
| 8(G) | V | 47.6 | 33.1 | Circle the figure divided in thirds |
| 9(I) | I | 87.0 | 82.7 | 9 + 6 = __ |
| 9(I) | II | 78.5 | 69.0 | 50 + 20 = __ |
| 9(I) | III | 43.9 | 37.7 | 400 + 65 = __ |
| 9(I) | IV | 67.3 | 69.1 | 73 + 6 = __ |
| 9(I) | V | 81.2 | 68.3 | 58 + 5 = __ |
| 10(I) | I | 57.8 | 57.3 | Write the value of this group of money: 50c + 50c |
| 10(I) | II | 50.6 | 41.6 | Write the value of this group of money: 5c + 50c |
| 10(I) | III | 49.0 | 48.1 | Write the value of this group of money: 25c + 10c + 5c |
| 10(I) | IV | 46.5 | 46.4 | Write the value of this group of money: 10c + 50c |
| 10(I) | V | 41.6 | 36.5 | Write the value of this group of money: 25c + 10c + 25c |
| 11(I) | I | 70.2 | 57.3 | 723<br>−621 |
| 11(I) | II | 65.8 | 43.4 | 376<br>− 56 |
| 11(I) | III | 69.7 | 36.8 | 76<br>− 5 |
| 11(I) | IV | 73.6 | 64.6 | 66<br>−64 |
| 11(I) | V | 68.8 | 49.0 | 7533<br>−2010 |

(TABLE A, cont.)

| Exercise (type)[a] | Item form | Percentage correct |  | Description of exercise |
|---|---|---|---|---|
|  |  | Experimental | Control |  |
| 12(G) | I | 64.2 | 33.0 | How much is 800 plus 25? |
| 12(G) | II | 78.3 | 73.7 | How much is 40 plus 50? |
| 12(G) | III | 90.5 | 94.7 | How much is 7 plus 5? |
| 12(G) | IV | 84.9 | 90.1 | How much is 48 plus 4? |
| 12(G) | V | 88.0 | 89.0 | How much is 33 plus 2? |
| 13(I) | I | 79.5 | 64.6 | 8−6 = __ |
| 13(I) | II | 63.9 | 48.7 | 60−40 = __ |
| 13(I) | III | 56.1 | 38.7 | 69−9 = __ |
| 13(I) | IV | 56.6 | 55.5 | 17−8 = __ |
| 13(I) | V | 72.1 | 50.0 | 13−5 = __ |
| 14(G) | I | 56.6 | 56.3 | How much is 70 minus 60? |
| 14(G) | II | 76.5 | 60.6 | How much is 16 minus 8? |
| 14(G) | III | 78.3 | 77.7 | How much is 11 minus 4? |
| 14(G) | IV | 93.5 | 90.1 | How much is 8 minus 4? |
| 14(G) | V | 77.1 | 56.7 | How much is 85 minus 5? |
| 15(I) | I | 51.6 | 38.2 | 570<br>+ 93 |
| 15(I) | II | 71.5 | 61.1 | 64<br>+28 |
| 15(I) | III | 72.9 | 51.0 | 667<br>+204 |
| 15(I) | IV | 64.2 | 53.6 | 147<br>+667 |
| 15(I) | V | 74.7 | 56.7 | 39<br>+68 |
| 16(G) | I | 87.4 | 71.4 | How much is 2 times 3? |
| 16(G) | II | 57.2 | 49.5 | How much is 6 divided by 2? |
| 16(G) | III | 76.4 | 88.3 | How much is 3 times 5? |
| 16(G) | IV | 92.1 | 87.4 | How much is 4 times 2? |
| 16(G) | V | 57.8 | 48.0 | How much is 8 divided by 4? |
| 17(I) | I | 32.9 | 22.7 | 546<br>−127 |

(TABLE A, cont.)

| Exercise (type)[a] | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Experimental | Control | |
| 17(I) | II | 47.5 | 23.9 | 82<br>−59 |
| 17(I) | III | 31.6 | 12.3 | 865<br>−497 |
| 17(I) | IV | 23.9 | 22.7 | 4734<br>−1917 |
| 17(I) | V | 43.5 | 13.5 | 67<br>− 8 |
| 18(G) | I | 54.1 | 25.0 | Write what time it is on that clock (4:00) |
| 18(G) | II | 9.0 | 3.0 | Write what time it is on that clock (2:30) |
| 18(G) | III | 11.5 | 26.6 | Write what time it is on that clock (8:15) |
| 18(G) | IV | 85.7 | 77.5 | How many days are there in a week? |
| 18(G) | V | 87.4 | 88.2 | Which is the longest? (month day year) |
| 19(I) | I | 64.6 | 58.2 | 2413<br>× 2 |
| 19(I) | II | 86.7 | 74.3 | 4<br>×2 |
| 19(I) | III | 50.3 | 44.3 | 324<br>× 3 |
| 19(I) | IV | 45.3 | 51.8 | 36<br>× 2 |
| 19(I) | V | 76.6 | 63.5 | 32<br>× 3 |
| 20(G) | I | 2.5 | 1.8 | Write how many grams there are in a kilogram |

(TABLE A, cont.)

| Exercise (type)* | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Experimental | Control | |
| 20(G) | II | 83.7 | 84.9 | Circle the parallel lines |
| 20(G) | III | 44.6 | 73.4 | Circle the angle |
| 20(G) | IV | 37.4 | 32.4 | Which is longer? (decimeter centimeter meter) |
| 20(G) | V | 44.6 | 50.4 | Write how many centimeters there are in a meter |
| 21(I) | I | 50.9 | 41.8 | 12÷3 |
| 21(I) | II | 67.1 | 59.3 | 6÷2 |
| 21(I) | III | 66.5 | 48.1 | 8÷4 |
| 21(I) | IV | 66.5 | 64.6 | 9÷3 |
| 21(I) | V | 71.4 | 70.2 | 8÷2 |
| 22(I) | I | 72.7 | 71.8 | In that square there is money ($2 and $2). Mr. José is going to buy a melon. The melon which he wants costs 3 córdobas. Write how many córdobas will be returned to him. |
| 22(I) | II | 77.2 | 77.0 | In that square there is money ($10). Mr. José is going to buy a melon. The melon which he wants costs 3 córdobas. Write how many córdobas will be returned to him. |
| 22(I) | III | 76.1 | 71.7 | In that square there is money ($5). Mr. José is going to buy a melon. The melon which he wants costs 3 córdobas. Write how many córdobas will be returned to him. |
| 22(I) | IV | 44.0 | 41.8 | In that square there is money ($50). Mr. José is going to buy a melon. The melon which he wants costs 3 córdobas. Write how many córdobas will be returned to him. |

(TABLE A, cont.)

| Exercise (type)[a] | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Experimental | Control | |
| 22(I) | V | 66.2 | 61.5 | In that square there is money ($20). Mr. José is going to buy a melon. The melon which he wants costs 3 córdobas. Write how many córdobas will be returned to him. |
| 23(I) | I | 36.7 | 29.1 | 2/5−1/5 |
| 23(I) | II | 39.9 | 34.5 | 2/10 + 5/10 |
| 23(I) | III | 52.3 | 34.9 | 1/3 + 1/3 |
| 23(I) | IV | 47.2 | 45.5 | 2/5 + 1/5 |
| 23(I) | V | 41.6 | 20.2 | 5/10−2/10 |
| 24(G) | I | 69.8 | 44.6 | Roger arrived at school at 8:00 and Luis arrived 2 hours later. What time did Luis arrive?<br>(6:00 8:00 10:00 12:00) |
| 24(G) | II | 38.6 | 37.4 | Mr. Sánchez's oxen are able to plough 4 fields a day. How many fields are they able to plough in half a day?<br>(4 1/2 2 8) |
| 24(G) | III | 86.6 | 72.3 | José's mother made 12 biscuits. José ate 5. How many biscuits were left?<br>(5 12 17 7) |
| 24(G) | IV | 83.5 | 84.7 | Elena ate 4 mamones and then ate 3 more. Chico ate 5 mamones. How many did they eat in all?<br>(12 9 8 7) |
| 24(G) | V | 64.5 | 68.5 | Mrs. López sold 4 chickens for 3 cordobas each. How much money did she make?<br>(C9 C12 C3 C7) |

(TABLE A, cont.)

| Exercise (type)[a] | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Experimental | Control | |
| 25(I) | I | 77.6 | 75.5 | Juan had 5 mangos and ate 2. How many does he have now? (3 10 7) |
| 25(I) | II | 77.9 | 77.9 | Eva has 3 toys. Manolo has 3 others. How many toys do they have together? (6 9 3) |
| 25(I) | III | 69.7 | 75.5 | María has 4 dahlias and 2 roses. How many flowers does she have in all? (2 6 8) |
| 25(I) | IV | 13.8 | 13.6 | María has 6 caramels. Pedro has 5. María has more. How many more? (11 3 1) |
| 25(I) | V | 81.2 | 75.0 | Nina bought 6 oranges. Her mother gave her 1 more. How many oranges does Nina have now? (6 7 5) |

[a] Items labeled I are individual items, those labeled G are group items

TABLE B

Performance of Experienced and Nonexperienced Students on 1977 Second-grade Posttest

| Exercise (type)[a] | Item form | Percentage correct |  | Description of exercise |
|---|---|---|---|---|
|  |  | Nonexperienced students | Experienced students |  |
| 1(I) | I | 31.3 | 47.4 | Write the number that comes after 349 |
| 1(I) | II | 76.7 | 78.6 | Write the number that comes after 71 |
| 1(I) | III | 52.5 | 53.1 | Write the number that comes after 682 |
| 1(I) | IV | 63.9 | 73.5 | Write the number that comes after 39 |
| 1(I) | V | 59.7 | 71.1 | Write the number that comes after 306 |
| 2(I) | I | 81.3 | 85.6 | Count the beans and write the numeral on the line (25 beans) |
| 2(I) | II | 81.7 | 89.8 | Count the beans and write the numeral on the line (32 beans) |
| 2(I) | III | 96.6 | 96.9 | Count the beans and write the numeral on the line (8 beans) |
| 2(I) | IV | 88.5 | 91.8 | Count the beans and write the numeral on the line (17 beans) |
| 2(I) | V | 82.5 | 82.5 | Count the beans and write the numeral on the line (40 beans) |
| 3(I) | I | 7.8 | 5.2 | Circle the largest number (1/4 1/2 1/3) |
| 3(I) | II | 70.0 | 69.4 | Circle the largest number (923 479 150) |
| 3(I) | III | 78.0 | 87.5 | Circle the largest number (59 73 75) |
| 3(I) | IV | 3.3 | 2.0 | Circle the largest number (1/10 1/5 1/4) |
| 3(I) | V | 40.4 | 53.6 | Circle the largest number (34 401 149) |
| 4(G) | I | 91.8 | 86.7 | Circle 7359 (3759 9537 7359 7539) |

(TABLE B, cont.)

| Exercise (type)[a] | Item form | Percentage correct |  | Description of exercise |
|---|---|---|---|---|
|  |  | Nonexperienced students | Experienced students |  |
| 4(G) | II | 96.8 | 94.4 | Circle 690<br>(69 690 960 96) |
| 4(G) | III | 83.3 | 90.1 | Circle 706<br>(706 760 607 76) |
| 4(G) | IV | 84.2 | 96.7 | Circle 74<br>(40 74 47 70) |
| 4(G) | V | 95.1 | 97.1 | Circle 241<br>(142 421 251 241) |
| 5(G) | I | 88.5 | 94.9 | Write 237 |
| 5(G) | II | 58.5 | 51.4 | Write 2999 |
| 5(G) | III | 71.2 | 80.2 | Write 608 |
| 5(G) | IV | 89.5 | 82.5 | Write 71 |
| 5(G) | V | 91.8 | 86.7 | Write 830 |
| 6(G) | I | 60.7 | 69.4 | Circle the 8th soldier |
| 6(G) | II | 95.7 | 100.0 | Circle the 2nd soldier |
| 6(G) | III | 89.4 | 89.0 | Circle the 4th soldier |
| 6(G) | IV | 26.3 | 49.2 | Circle the 10th soldier |
| 6(G) | V | 83.6 | 73.3 | Circle the 6th soldier |
| 7(I) | I | 79.7 | 83.5 | 842<br>+ 41 |
| 7(I) | II | 83.3 | 81.6 | 41<br>+30 |
| 7(I) | III | 81.4 | 83.3 | 3886<br>+5102 |
| 7(I) | IV | 72.1 | 73.5 | 504<br>+132 |
| 7(I) | V | 77.2 | 76.3 | 26<br>+ 3 |
| 8(G) | I | 82.0 | 87.8 | Circle the figure divided in half |
| 8(G) | II | 84.0 | 81.9 | Circle the figure divided in fourths |

(TABLE B, cont.)

| Exercise (type)[a] | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Nonexperienced students | Experienced students | |
| 8(G) | III | 83.3 | 89.0 | Circle the figure divided in fifths |
| 8(G) | IV | 47.4 | 68.3 | Circle the figure divided in tenths |
| 8(G) | V | 55.7 | 42.9 | Circle the figure divided in thirds |
| 9(I) | I | 85.9 | 87.6 | 9 + 6 = __ |
| 9(I) | II | 75.0 | 80.6 | 50 + 20 = __ |
| 9(I) | III | 39.0 | 46.9 | 400 + 65 = __ |
| 9(I) | IV | 67.2 | 67.4 | 73 + 6 = __ |
| 9(I) | V | 82.5 | 80.4 | 58 + 5 = __ |
| 10(I) | I | 64.1 | 53.6 | Write the value of this group of money: 50c + 50c |
| 10(I) | II | 35.0 | 60.2 | Write the value of this group of money: 5c + 50c |
| 10(I) | III | 44.1 | 52.1 | Write the value of this group of money: 25c + 10c + 5c |
| 10(I) | IV | 45.9 | 46.9 | Write the value of this group of money: 10c + 50c |
| 10(I) | V | 40.4 | 42.3 | Write the value of this group of money: 25c + 10c + 25c |
| 11(I) | I | 73.4 | 68.0 | 723<br>−621 |
| 11(I) | II | 61.7 | 68.4 | 376<br>− 56 |
| 11(I) | III | 67.8 | 70.8 | 76<br>− 5 |
| 11(I) | IV | 65.6 | 78.6 | 66<br>−64 |

(TABLE B, cont.)

| Exercise (type)[a] | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Nonexperienced students | Experienced students | |
| 11(I) | V | 61.4 | 73.2 | 7538<br>−2010 |
| 12(G) | I | 52.5 | 71.4 | How much is 800 plus 25? |
| 12(G) | II | 74.5 | 83.3 | How much is 40 plus 50? |
| 12(G) | III | 90.9 | 90.1 | How much is 7 plus 5? |
| 12(G) | IV | 89.5 | 84.2 | How much is 48 plus 4? |
| 12(G) | V | 88.5 | 87.6 | How much is 33 plus 2? |
| 13(I) | I | 79.7 | 79.4 | 8−6 = ___ |
| 13(I) | II | 71.7 | 59.2 | 60−40 = ___ |
| 13(I) | III | 55.9 | 56.3 | 69−9 = ___ |
| 13(I) | IV | 50.8 | 60.2 | 17−8 = ___ |
| 13(I) | V | 61.4 | 78.4 | 13−5 = ___ |
| 14(G) | I | 39.3 | 67.4 | How much is 70 minus 60? |
| 14(G) | II | 73.4 | 80.6 | How much is 16 minus 8? |
| 14(G) | III | 69.7 | 84.6 | How much is 11 minus 4? |
| 14(G) | IV | 89.5 | 94.2 | How much is 8 minus 4? |
| 14(G) | V | 75.4 | 78.1 | How much is 85 minus 5? |
| 15(I) | I | 50.0 | 52.6 | 570<br>+ 93 |
| 15(I) | II | 68.3 | 73.5 | 64<br>+28 |
| 15(I) | III | 62.7 | 79.2 | 667<br>+204 |
| 15(I) | IV | 60.7 | 66.3 | 147<br>+667 |
| 15(I) | V | 80.7 | 71.1 | 39<br>+68 |
| 16(G) | I | 82.0 | 90.8 | How much is 2 times 3? |
| 16(G) | II | 62.8 | 50.0 | How much is 6 divided by 2? |
| 16(G) | III | 66.7 | 83.5 | How much is 3 times 5? |

(TABLE B, cont.)

| Exercise (type)[a] | Item form | Percentage correct |  | Description of exercise |
|---|---|---|---|---|
|  |  | Nonexperienced students | Experienced students |  |
| 16(G) | IV | 94.7 | 91.7 | How much is 4 times 2? |
| 16(G) | V | 59.0 | 57.1 | How much is 8 divided by 4? |
| 17(I) | I | 31.3 | 34.0 | 546<br>−127 |
| 17(I) | II | 50.0 | 45.9 | 82<br>−59 |
| 17(I) | III | 28.8 | 33.3 | 865<br>−497 |
| 17(I) | IV | 24.6 | 23.5 | 4734<br>−1917 |
| 17(I) | V | 33.3 | 49.5 | 67<br>− 8 |
| 18(G) | I | 34.4 | 66.3 | Write what time it is on that clock (4:00) |
| 18(G) | II | 8.5 | 9.7 | Write what time it is on that clock (2:30) |
| 18(G) | III | 15.2 | 8.8 | Write what time it is on that clock (8:15) |
| 18(G) | IV | 47.4 | 91.7 | How many days are there in a week? |
| 18(G) | V | 85.3 | 88.6 | Which is the longest? (month day year) |
| 19(I) | I | 65.6 | 63.9 | 2413<br>× 2 |
| 19(I) | II | 83.3 | 88.8 | 4<br>×2 |
| 19(I) | III | 47.5 | 52.1 | 324<br>× 3 |
| 19(I) | IV | 41.0 | 48.0 | 36<br>× 2 |

(TABLE B, cont.)

| Exercise (type)[a] | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Nonexperienced students | Experienced students | |
| 19(I) | V | 63.2 | 84.5 | $\begin{array}{r}32\\ \underline{\times\ 3}\end{array}$ |
| 20(G) | I | 1.6 | 3.1 | Write how many grams there are in a kilogram |
| 20(G) | II | 79.8 | 88.9 | Circle the parallel lines |
| 20(G) | III | 40.9 | 47.3 | Circle the angle |
| 20(G) | IV | 5.3 | 42.5 | Which is longer? (decimeter centimeter meter) |
| 20(G) | V | 39.3 | 47.6 | Write how many centimeters there are in a meter |
| 21(I) | I | 43.8 | 55.7 | 12÷3 |
| 21(I) | II | 71.7 | 64.3 | 6÷2 |
| 21(I) | III | 67.8 | 65.6 | 8÷4 |
| 21(I) | IV | 55.7 | 70.4 | 9÷3 |
| 21(I) | V | 61.4 | 77.3 | 8÷2 |
| 22(I) | I | 81.3 | 67.0 | In that square there is money ($2 and $2). Mr. José is going to buy a melon. The melon which he wants costs 3 córdobas. Write how many córdobas will be returned to him. |
| 22(I) | II | 81.7 | 74.5 | In that square there is money ($10). Mr. José is going to buy a melon. The melon which he wants costs 3 córdobas. Write how many córdobas will be returned to him. |
| 22(I) | III | 74.6 | 77.1 | In that square there is money ($5). Mr. José is going to buy a melon. The melon which he wants costs 3 córdobas. Write how many córdobas will be returned to him. |

(TABLE B, cont.)

| Exercise (type)$^{a}$ | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Nonexperienced students | Experienced students | |
| 22(I) | IV | 42.6 | 44.9 | In that square there is money ($50). Mr. José is going to buy a melon. The melon which he wants costs 3 córdobas. Write how many córdobas will be returned to him. |
| 22(I) | V | 54.4 | 73.2 | In that square there is money ($20). Mr. José is going to buy a melon. The melon which he wants costs 3 córdobas. Write how many córdobas will be returned to him. |
| 23(I) | I | 28.1 | 42.3 | 2/5−1/5 |
| 23(I) | II | 31.7 | 44.9 | 2/10 + 5/10 |
| 23(I) | III | 40.7 | 59.4 | 1/3 + 1/3 |
| 23(I) | IV | 32.8 | 56.1 | 2/5 + 1/5 |
| 23(I) | V | 21.1 | 53.6 | 5/10−2/10 |
| 24(G) | I | 73.8 | 67.4 | Roger arrived at school at 8:00 and Luis arrived 2 hours later. What time did Luis arrive?<br>(6:00 8:00 10:00 12:00) |
| 24(G) | II | 35.1 | 43.1 | Mr. Sánchez's oxen are able to plough 4 fields a day. How many fields are they able to plough in half a day?<br>(4 1/2 2 8) |
| 24(G) | III | 87.9 | 85.7 | José's mother made 12 biscuits. José ate 5. How many biscuits were left?<br>(5 12 17 7) |
| 24(G) | IV | 79.0 | 84.2 | Elena ate 4 mamones and then ate 3 more. Chico ate 5 mamones. How many did they eat in all?<br>(12 9 8 7) |

(TABLE B, cont.)

| Exercise (type)[a] | Item form | Percentage correct | | Description of exercise |
|---|---|---|---|---|
| | | Nonexperienced students | Experienced students | |
| 24(G) | V | 75.4 | 58.1 | Mrs. López sold 4 chickens for 3 córdobas each. How much money did she make?<br>(C9 C12 C3 C7) |
| 25(I) | I | 79.7 | 76.3 | Juan had 5 mangos and ate 2. How many does he have now?<br>(3 10 7) |
| 25(I) | II | 73.3 | 80.6 | Eva has 3 toys. Manolo has 3 others. How many toys do they have together?<br>(6 9 3) |
| 25(I) | III | 64.4 | 72.9 | María has 4 dahlias and 2 roses. How many flowers does she have in all?<br>(2 6 8) |
| 25(I) | IV | 9.8 | 16.3 | María has 6 caramels. Pedro has 5. María has more. How many more?<br>(11 3 1) |
| 25(I) | V | 77.2 | 83.5 | Nina bought 6 oranges. Her mother gave her 1 more. How many oranges does Nina have now?<br>(6 7 5) |

[a] Items labeled I are individual items, those labeled G are group items.

# *Chapter 3*

# FORMAL EVALUATION OF THE 1976 FIRST–GRADE INSTRUCTIONAL PROGRAM

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THIS CHAPTER reports on an experimental evaluation of the first-grade radio mathematics program. During 1976 the first-grade lessons were broadcast by the national radio station and were used in approximately 50 classrooms, 30 of which served as experimental classrooms for the formal evaluation reported here. The experimental program is fully described in Searle, Friend, and Suppes (1976); we present here brief characterizations of both the experimental and the traditional instructional programs and then describe the experimental design, sampling procedures, and testing instruments used to assess the effectiveness of the programs. Finally, we present the results. Anticipating this final section, we remark that the first-grade radio instructional program has produced levels of student achievement in mathematics that are higher than those of similar students in traditional classrooms and that these gains are statistically significant as well as educationally substantive.

## 1. THE RADIO INSTRUCTIONAL PROGRAM

The 1976 first-grade instructional program consisted of 150 30-minute radio lessons and teacher's guides for postbroadcast activities. Most lessons were accompanied by student worksheets.

During project radio lessons the students participated in a variety of instructional activities, responding to oral exercises as well as using the student worksheets. Other activities such as games, songs, and riddles were used to change the pace of lessons. The radio lessons were characterized by a high rate of student responses—four responses per minute on the average.

The instructional segments of the radio lesson dealt with different mathematical topics and required different types of student responses. Instructional material took the form of exercises supported by minimal amounts of explanation, and during each program the children worked from 40 to 50 mathematics exercises.

The topics of the first-grade curriculum were allocated to five major *strands*—number concepts, addition, subtraction, applications, and measurement. Within each strand the topics were subdivided into exercise classes, which in turn were used to construct the lesson segments that comprised both the radio and postbroadcast portions of the mathematics lessons. The full curriculum consisted of 563 exercise classes, from which 1,314 lesson segments were constructed.

Fifty-four classrooms in the Nicaraguan departments of Masaya, Granada, and Carazo were used in the evaluation of the radio instructional program—30 experimental (radio) classes and 24 control (traditional) classes. (The selection of these classes is described in a later section.)

First-grade radio lessons (in Spanish) were broadcast each schoolday morning at 9:00 A.M. through the facilities of the national radio system, Radiodifusora Nacional. Each lesson occupied approximately 25 minutes of the 30-minute time slot. The remaining time was filled with an introductory announcement, a closing announcement, a countdown immediately preceding the lesson, music, and occasional short announcements for teachers. The project purchased and distributed the radios, but schools without electricity were expected to supply their own batteries.

Two major broadcasting difficulties occurred during the year: power failures at the radio station and preemption of radio time by political events. In addition, errors made by radio engineers resulted in the loss of some lesson time.

Student worksheets and teacher's guides were distributed monthly through the office of the School Inspector in each department. Teachers obtained their monthly paychecks at these offices and the materials were delivered to the office prior to their scheduled visits.

Each teacher participating in the program attended two 3-hour teacher training sessions held before school started in February. These sessions were used to discuss the teacher's role during radio lessons, the mechanics of material distribution and use, and the relation of the radio lessons' content to the official mathematics curriculum. Teachers were also given the opportunity to listen to lessons and to learn more about the goals of the project.

For most experimental classes, contact between project personnel and teachers of the experimental classes was strictly regulated and kept to a minimum. After the teacher training sessions, all information flow between the project and these teachers occurred through two channels—the radio and the office of the School Inspector in each department. An exception to this procedure was made for eight classes that were part of a weekly testing program. These classes were visited about every two weeks, at a time other than the mathematics period, for the administration of a 20-minute mathematics test.

Supervision of experimental classes was not undertaken by the project. Teachers of experimental classes were supervised by the regular school inspectors in the same way as teachers of traditional classes. However, departmental school inspectors do not have cars and they rarely visit schools. Project personnel made occasional unannounced visits to schools during broadcast time to observe whether the radio lessons were being used by the teachers in experimental classes. On the average, three such visits were made to each school during the year.

The project employed one procedure that was meant to be an indirect means of supervision. (We do not know whether it was perceived by teachers in this way.) Each month, one segment of a radio lesson was identified as a test, and the teachers were asked to return the students' worksheets for this lesson to the office of the School Inspector. These worksheets were packaged separately and teachers were reminded of the tests by radio for several days before they took place. A record was kept of the number of worksheets returned each month by each teacher; the returned worksheets were examined to determine if teachers had graded the papers to evaluate student performance as suggested in the teacher's guide.

We can summarize the description of the radio instructional program by listing the components of the experimental treatment.

1. Radio mathematics lessons, approximately 25 minutes long, broadcast once each school day at a fixed time.
2. Teacher's guides, containing (a) specific tasks for teachers before, during, and after the broadcast and (b) a general description of the material to be taught in the radio lessons and the material that should be taught by the classroom teacher.
3. Individual student worksheets for most lessons.
4. Several sets of supplementary materials for use during or after the radio lessons (e.g., posters, cardboard rulers).
5. Tests administered to all students once a month by radio, with answer keys in the teacher's guide.

6. Two 3-hour teacher training sessions at the beginning of the school year.
7. Occasional and irregular visits of project personnel to schools.

## 2. THE TRADITIONAL INSTRUCTIONAL PROGRAM

The traditional mathematics program in Nicaragua cannot be described in as much detail as the experimental program. The official curriculum is described in a guide prepared by the Ministry of Education. The guide is not supplied free for teachers but can be purchased at bookstores in the capital city of Managua. It presents a week-by-week outline of the topics that teachers are expected to cover, with many suggested exercises and practice procedures. No textbooks or supplementary materials are provided by school authorities; many teachers make or buy their own supplies. About five years ago an AID program financed the distribution of mathematics textbooks to schools. These books were intended to be used as student workbooks but some teachers did not allow students to write in them in order to preserve them for later use. They were seen occasionally in classrooms by project personnel.

Information was obtained about the traditional instructional program by systematic observations of traditional classrooms in June 1974 before radio lessons were instituted. Twenty-eight mathematics classes were observed—15 in urban schools and 13 in rural schools.

All the classrooms had chalkboards, but other teaching aids were generally absent. Students were using textbooks in only one classroom. Class size ranged from 18 to 46 students with a mean of 31 and a median of 30. However, this was the fourth month of school and the number of children attending classes when the observations were made was approximately two-thirds of the number matriculated.

In half the classes observed the students were separated into ability groups. Eleven of these classes were in rural schools and three were in urban schools. The majority were at the first-grade level. Most classes had two ability groups, but several had either three or four. The observers noted that in most of the classrooms with ability groups the teachers spent more time with the highest groups than with the others. During one particular classroom observation the high-ability group received 40 minutes of teacher direction, whereas the low-ability group received only 5 minutes.

The content being taught in first grade ranged from counting to 10 to division. In many of the classrooms the major activity was copying computation exercises from the chalkboard and solving them in student notebooks. There was little work with concrete materials; although eight classes used materials during the lesson, in three of the classes the materials were used by only a few children and in most cases they were used for only a short part of the lesson.

The classroom observations are summarized here to give the reader a sense of what happens in traditional classrooms. These observations did not form the basis for our characterization of the traditional instructional program; the objectives of that program were taken to be those published by the Ministry of Public Education.

## 3. DESIGN AND SAMPLING PROCEDURES

The effectiveness of project lessons was assessed using a randomized field experiment (Riecken & Boruch, 1974). Because the experimental treatment (the radio instructional program) was administered to intact classrooms, the sampling procedures assigned classrooms to treatments.

The population of first-grade classrooms was stratified by department and by school location (rural or urban), and equal numbers of classes were chosen from each stratum. In each of the three departments, eight classes were designated as control—four each in urban and rural schools; 10 classes were designated as experimental—five each in urban and rural schools. The three departments—Masaya, Granada, and Carazo—are roughly equal in size; in 1971 the respective numbers of primary-school students in the departments were 17,600, 13,500, and 15,400. Approximately 30% of the students in each department are in rural schools.

The strategy was to designate *schools* randomly as experimental or control and then to select classrooms at random within these designations. This was done to prevent the occurrence of a control and an experimental class in the same school with the attendant problems of contamination. The initial pool contained all public primary schools except those with a 1975 first-grade matriculation of less than 15 students, those that had previously used the project radio lessons, and two schools in Carazo affiliated with a teacher training school.

The first step in selecting classes was to prepare a list of schools with eligible classrooms for each of the six subpopulations formed by stratifying by department and location. Then lists of experimental and control schools were prepared by random assignment from the master list for each subpopulation. Schools were used in the order in which they appeared on the prepared list. One school refused to participate and was replaced by the next on the list. If a school had more than one first-grade section, one section was selected at random and assigned to the appropriate treatment. The result was a set of 30 experimental classrooms and 24 control classrooms. None of the teachers of these classes had prior experience with the project lessons and it is unlikely, although not absolutely certain, that any of the students did.

Because the difficulty of randomly assigning units (i.e., subjects, classrooms, or other groups) to treatments is often cited as an obstacle to using experimental techniques in the field (Boruch, 1975), it seems important to discuss our use of this technique. At the outset of our work in Nicaragua we alerted all of the education officials with whom we worked of our intention to choose experimental and control classes at random and very early obtained the permission of the Minister of Education to use this procedure. To assure the success of the experiment we required that all usage of the experimental lessons be with our permission, even in classrooms that were not part of the research design. We refused all requests to participate from teachers in schools that had been designated as control, even if there were no classes from that school in the present control group. Thus, the ease with which we were able to impose random assignment can probably be attributed to three factors: First, we made our intention known from the outset; second, we received official approval and support for the policy; and, third, we established clear and consistent procedures, implemented from the beginning of our work, for the use of the program.

## 4. MATHEMATICS ACHIEVEMENT TESTS

Students in control and experimental classes were administered both a pretest and a posttest. The results of these tests were used to compare the effectiveness of the radio instructional program with that of the mathematics program found in traditional classrooms.

### *Pretest*

The pretest was a modified version of the mathematics section of the kindergarten-level *Test of Basic Experiences* (TOBE), published by CTB/McGraw–Hill in both English and Spanish. The Spanish version of the test was developed for Spanish-speaking students in the United States; the modifications made to adapt the test for use in Nicaragua are described in Searle et al. (1976). The content of the 28-item test includes numeration, fractions, ordinal numbers, geometry, telling time, weight, length, size, and other basic concepts. Each item is presented orally and the student responds by marking one of four pictures displayed in a printed test booklet with one item per page.

It is not possible to compare performance of Nicaraguan and American children on the TOBE test because the test was altered for the Nicaraguan administration (and the publisher did not standardize the test on a Spanish-speaking population). However, results from an administration of the test in 1975 indicate that several properties of the test were similar for the English and Nicaraguan versions. The reliabilities were comparable—the KR-20 reliability coefficients were .82 and .83 for the Nicaraguan and English versions, respectively. The standard error of measurement for the Nicaraguan version was 1.91, compared with 2.10 for the English version.

### *Posttest*

All project tests, except the TOBE test just described, were developed by the project, for several reasons. First, there are no standardized tests in use in Nicaragua and we were unable to find suitable versions of achievement tests in Spanish for which data were available and which would be appropriate for the Nicaraguan setting. Furthermore, it seemed important to have a test designed to assess achievement of the objectives of the Nicaraguan curriculum. Such a strategy would increase the likelihood of detecting performance differences attributable to the teaching method adopted—traditional or radio. Finally, it seemed important to adopt a test design that would provide information about achievement on each topic in the curriculum in order to investigate not only the overall effectiveness of the program, but also its impact on different portions of the curriculum. A multiple matrix-sampling design satisfied this requirement (Shoemaker, 1973).

The evolution of the design for the first-grade posttest is described in Searle et al. (1976). The test used two types of items, **G** *items* that were read aloud to an entire class and **I** *items* that varied among individuals in a classroom. (**G** is an abbreviation for group, **I** for individual.) The distinction between the item types will be clarified by some examples.

| Oral component | Written component | |
|---|---|---|
| | **G** items | |
| "What is 2 plus 2?" | ____ | |
| "Circle the number 84." | 48 84 74 47 | |
| | **I** items | |
| "Find the sum." | $\begin{array}{r}12\\ +\ 3\\ \hline\end{array}$ | or |
| | 2 + 2 = ____ | or |
| | 21 + 14 = ____ | |
| "Circle the largest number." | 2 5 9 | or |
| | 21 12 32 | or |
| | 79 77 81 | |

The matrix-sampling structure of the test, which had four **I**-item forms (**I** forms) and four **G**-item forms (**G** forms), is shown in Figure 1. All **I** items were tested in every classroom; one-fourth of all **G** items were tested in each classroom. Sixteen different types of test papers were assembled—each **G** form paired with each **I** form. **G** forms were assigned at random to classrooms, and test papers containing the correct **G** form and one of the **I** forms were distributed at random to students within the classroom.

The test contained 40 **I** items and 44 **G** items. These 84 items were used to assess student achievement on approximately 30 instructional objectives of the radio curriculum. In addition, they provided information about a few topics that were part of the official curriculum but were not taught in experimental classrooms. The topics covered by the test are discussed in the results section of this chapter.

### *Test Administration*

Both the pretest and the posttest were administered by the project staff, rather than by the classroom teachers. For greater uniformity of administration, the posttest had tape-recorded instructions. All instructions for both tests had been checked in pilot tests and modified on the basis of classroom trials (in classrooms not otherwise involved with the project). Results from earlier administrations of the tests showed that students were able to follow the directions for responding.

At the beginning of the year, first-grade classrooms were quite crowded and the seating arrangements would have made it easy to copy. Therefore, test administrators were instructed first to excuse all children 6 years of age and under. (These students are not fully matriculated; the official school-admission age is 7 years.) Then, children were removed at random (by referring to the teacher's class list) until the number of students was reduced to the number of seats available, leaving an empty space between children who sat on benches. At the end of the year, if a room could accommodate all the children in the above manner, all were posttested. If not, then the names of those who had been pretested were read and those children were given priority for taking the posttest; others were chosen at random until the room was filled.

The pretest was administered in the period between February 23 and March 29, at the beginning of the school year. The posttest was administered between October 10 and November 15, at the end of the school year. In both cases, the distribution of the testing of experimental and control classes was roughly equal over the entire testing period.

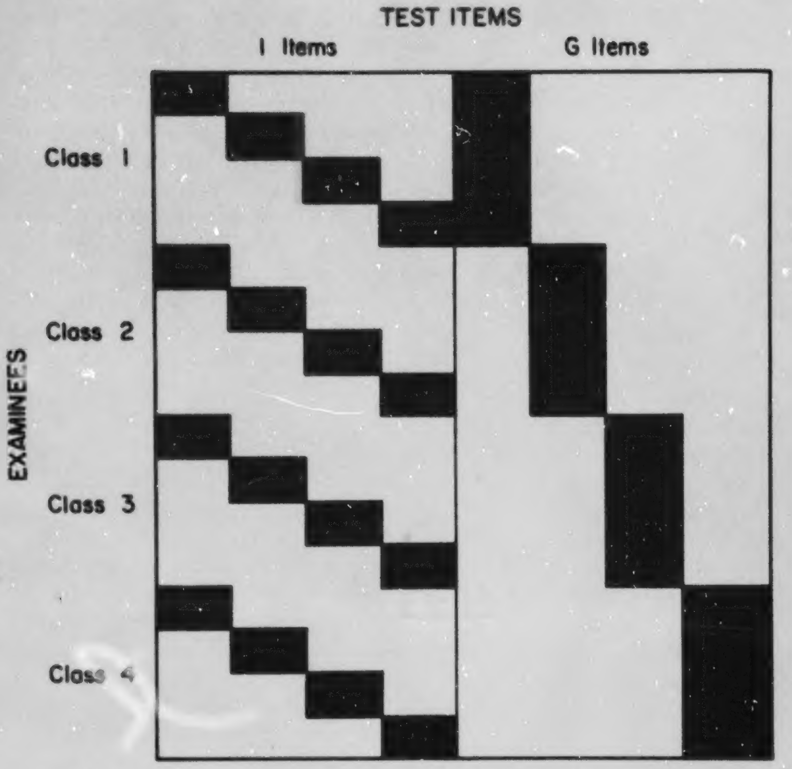

FIGURE 1. Matrix-sampling design of first-grade achievement test.

## 5. DATA ANALYSIS

A combination of analysis strategies was used to understand the test data fully. The matrix sampling procedure described above aims to achieve inferential validity by randomly assigning units along two dimensions—in this case schools and test forms. Thus, urban and rural schools were randomly assigned to experimental or control conditions and test forms were randomly assigned to classrooms and students. Under the assumptions of random assignment, unbiased estimates of population test scores can be obtained for the treatment and control groups and the scores compared, even though not every student answered every test item.

While the matrix sampling test design was not intended to provide an analysis of individual differences, some assessment of the influence of variables such as pretest score and sex on posttest achievement is desirable. If, for example, the treatment and control groups did not have the same distributions of pretest scores, then the matrix sampling analyses may be subject to dispute. Because characteristics like pretest score and sex were not factors in the random assignment of individuals for the matrix sampling design, the effects of such characteristics must be taken into account statistically after the data are collected.

Multiple regression was the statistical method used to analyze individual differences, with posttest achievement expressed as a linear combination of observed factors. At the present time the project's data base can be used to identify the following factors.

1. pretest score
2. urban or rural
3. sex
4. experimental or control

It would also be desirable to consider additional factors such as age, parental income, and number of times previously enrolled in the same grade. As more data are received from Nicaragua, these and other factors will be considered.

Finally, posttest item scores were analyzed to determine whether the effects of the experimental program varied with content area. It was expected that the score differences between experimental and

TABLE 1

Number of Students in Different Testing Conditions in 1976 First-grade Testing Program

| Test period | Condition | Experimental | | Control | |
|---|---|---|---|---|---|
| | | *N* | % of total | *N* | % of total |
| Pretest | Pretest only | 342 | 49.1 | 260 | 46.1 |
| | Both pretest and posttest | 354 | 50.9 | 304 | 53.9 |
| | TOTAL | 696 | 100.0 | 564 | 100.0 |
| Posttest | Posttest only | 217 | 37.8 | 134 | 30.4 |
| | Both pretest and posttest | 354 | 62.2 | 304 | 69.6 |
| | TOTAL | 571 | 100.0 | 438 | 100.0 |

TABLE 2

Comparison of Pretest Scores for Groups in Different Testing Conditions: 1976 Grade 1

| Condition | Score[a] | | | | | |
|---|---|---|---|---|---|---|
| | Experimental | | | Control | | |
| | *N* | Mean | *SD* | *N* | Mean | *SD* |
| All students | 696 | 20.92 | 4.63 | 564 | 20.28 | 5.20 |
| Pretest only | 342 | 20.44 | 5.61 | 260 | 19.99 | 5.74 |
| Both pretest and posttest | 354 | 21.38 | 4.18 | 304 | 20.53 | 4.67 |

*Note.* Difference between pretest only and pretest and posttest: $F = 6.78$; $df = 1, 1256$; $p < .01$. Difference between experimental and control groups: $F = 4.96$; $df = 1, 1256$; $p < .01$.

[a] Maximum score = 28.

traditional students would be greater on those topics covered more thoroughly by the radio instructional program.

## 6. RESULTS

### *Sample Sizes for Pretest and Posttest*

The numbers of students taking the pretest and the posttest are shown in Table 1. Of those students taking the pretest, only about half also took the posttest. Of the children who took the posttest, about two-thirds had also taken the pretest. Of those students who did not take the pretest, some were present at the beginning of the school year but were not pretested because of overcrowded conditions. The remainder entered school after the beginning of the year. Unless otherwise noted, the analyses reported here use only the students with both pretest and posttest scores.

### *Pretest Results*

Average pretest scores are presented in Table 2, which compares the experimental and control groups. It also compares the pretest-only groups with the groups that took both the pretest and the posttest. (Item scores appear in App. A, Table A.) Approximate $F$-ratio statistics for a two-way analysis of variance were calculated for these comparisons by multiplying the variance of the means by the harmonic mean number of observations and dividing by a weighted average of within-cell variances. These $F$ statistics indicate that students who were not posttested had significantly lower ($p < .01$) pretest scores than students who were present for the posttest, and that the experimental group had significantly higher ($p < .01$) pretest scores than the control group. The former difference, while not large, is in the direction expected if students with lower ability as measured by pretest are more likely to drop out or be absent from school as the school year progresses. The difference between the experimental and control groups, while statistically significant, is small.

### *Matrix-sampling Analysis of Posttest*

As discussed earlier, the posttest contains two types of items—those given to all students in a classroom (**G** items) and those given to subsets of students within a classroom (**I** items). For purposes of the first analysis reported here we consider **G** and **I** forms as two separate tests, each with a matrix-sampling design. Methods described by Sirotnik (1974) were used to estimate means and standard errors for each test. The mean posttest scores for the experimental and control groups are obtained by adding the average scores for each test form, while the standard errors are calculated using a weighted average of items-by-students interaction variances (i.e., the residual variance after main effects of items and students have been removed) across the blocks of the matrix-sampling design.

The estimates in Table 3 show a superiority of the experimental group on both tests. For the **G** test, with 44 items, the means are 33.1 and 20.7 for experimental and control groups, respectively. For the **I** test, with 40 items, the respective means are 22.1 and 13.5.

The assumptions of this analysis are that both items and students have been assigned at random to forms. Neither of these conditions is exactly met in the present case. In particular, students are assigned to

TABLE 3

Matrix-sampling Estimates of Posttest Means and Standard Errors

| Test forms | Experimental[a] | | Control[b] | |
|---|---|---|---|---|
| | Mean | *SE* | Mean | *SE* |
| **G** | 33.1 | 1.0 | 20.7 | 1.4 |
| **I** | 22.1 | 1.2 | 13.5 | 1.2 |
| **G&I** | 55.2 | 1.6 | 34.2 | 1.8 |

[a] $N = 571$
[b] $N = 438$

**G** forms under the obvious restriction of their class membership. Thus, the assumption of randomness is relatively weak in the case of the **G** forms, in which all students in the class received the same form. Despite the deviations from the assumptions of randomness, the matrix-sampling analysis is useful in providing an estimate of the average test scores that would be obtained if every student responded to all test forms. The precision of an estimated mean can be evaluated by considering the estimated mean plus or minus twice its standard error. For the estimates of Table 3 the experimental group has scores on the order of 11 standard errors higher than the control group for the combined **G** and **I** forms, indicating a robust favorable effect of the experimental treatment on posttest achievement. However, formal tests of statistical significance are reserved for the more detailed analyses presented below.

### *Regression Analyses of Posttest*

Table 4 gives the distribution of students who took both pretest and posttest, classified by test form, urban/rural classroom, and sex. Recall that each student takes a subtest consisting of one **G** form and one **I** form, and that there are about twice as many urban as rural students. The random assignment of schools, classrooms, and test forms should give approximately equal numbers of students in the "rural" cells and the "urban" cells. The notable exception to this desired result is test form **G−2** where there are too few rural students in the control group.

Within the matrix-sampling design it is difficult to obtain individual posttest scores that permit comparison of all individuals, since the distribution of scores for various test forms may vary and no individual takes every test form. For the present data the sample sizes and number of test forms allow the option of performing separate regression analyses for each test form and then comparing regression results across test forms to observe consistent effects.

An alternative approach would be to add dichotomous (i.e., 0 or 1) variables to the regression corresponding to the effects of each test form. The multiple regression would then use the full data set and estimate test-form effects apart from the effects of other factors. However, this regression would assume that the distributions of scores for the posttest forms differ only in mean and that the effects of regression variables are the same for each test form. Because we were unwilling to make this assumption, a single regression analysis was not undertaken.

The multiple $R$s for each test-form regression indicated a significant degree of relationship ($p < .001$) between posttest achievement and a linear combination of the identified factors. Multiple $R$s

TABLE 4

Distribution of Students with
Both Pretest and Posttest

| Posttest form | Control | | Experimental | |
|---|---|---|---|---|
| | Rural | Urban | Rural | Urban |
| G–1 | | | | |
| Male | 26 | 11 | 17 | 40 |
| Female | 30 | 13 | 17 | 28 |
| G–2 | | | | |
| Male | 2 | 45 | 10 | 37 |
| Female | 0 | 43 | 19 | 38 |
| G–3 | | | | |
| Male | 21 | 19 | 14 | 44 |
| Female | 14 | 16 | 14 | 25 |
| G–4 | | | | |
| Male | 16 | 10 | 19 | 10 |
| Female | 18 | 20 | 12 | 10 |
| I–1 | | | | |
| Male | 16 | 20 | 16 | 29 |
| Female | 16 | 28 | 15 | 23 |
| I–2 | | | | |
| Male | 17 | 28 | 16 | 34 |
| Female | 21 | 20 | 14 | 24 |
| I–3 | | | | |
| Male | 16 | 12 | 11 | 35 |
| Female | 14 | 26 | 18 | 24 |
| I–4 | | | | |
| Male | 16 | 25 | 17 | 33 |
| Female | 11 | 18 | 15 | 30 |

and standard errors of estimation are presented in Table 5. These suggest that the separate regressions are comparable, in terms of variance accounted for and goodness of fit of the regression plane. Regression coefficients and beta weights (i.e., coefficients divided by their standard errors of estimation) are given in Tables 6 and 7, and beta weights are plotted across test forms in Figure 2. Beta-weight values greater than 1.65 may be considered "large" and values greater than 2.00 "strong." These results indicate that both treatment and pretest scores have strong effects on posttest scores for every test form, while the urban/rural variable has a weaker but consistent effect and sex has no large or consistent effect. Note that although significance tests are reported for each test-form regression, the regression results are evaluated primarily with regard to the consistency of results across regressions.

### TABLE 5

Multiple *R*s for Regression Analysis by Test Form

| Posttest form | *R* | *SE* |
|---|---|---|
| G–1 | .706 | 2.02 |
| G–2 | .610 | 2.31 |
| G–3 | .704 | 2.24 |
| G–4 | .651 | 2.21 |
| I–1 | .656 | 2.25 |
| I–2 | .552 | 2.41 |
| I–3 | .564 | 2.64 |
| I–4 | .714 | 2.32 |

### TABLE 6

Regression Coefficients for G Test Forms

| Form | Independent variables | Coefficient | Beta weight |
|---|---|---|---|
| G–1 | Constant | .993 | |
| | Pretest | .232 | 6.51* |
| | Urban/rural | –.036 | –.11 |
| | Sex | –.050 | –.16 |
| | Treatment | 3.061 | 9.21* |
| G–2 | Constant | –1.648 | |
| | Pretest | .273 | 6.84* |
| | Urban/rural | 1.796 | 3.65* |
| | Sex | –.353 | –1.05 |
| | Treatment | 3.037 | 8.51* |
| G–3 | Constant | –1.154 | |
| | Pretest | .283 | 7.01* |
| | Urban/rural | .533 | 1.40 |
| | Sex | –.375 | –1.06 |
| | Treatment | 3.002 | 8.33* |
| G–4 | Constant | 1.135 | |
| | Pretest | .191 | 4.09* |
| | Urban/rural | .658 | 1.56 |
| | Sex | .259 | .59 |
| | Treatment | 3.192 | 7.57* |

*$p < .001$

TABLE 7

Regression Coefficients for I Test Forms

| Form | Independent variable | Coefficient | Beta weight |
|---|---|---|---|
| I-1 | Constant | −3.685 | |
| | Pretest | .337 | 8.75*** |
| | Urban/rural | .307 | .84 |
| | Sex | −.351 | −.99 |
| | Treatment | 1.858 | 5.23*** |
| I-2 | Constant | −4.265 | |
| | Pretest | .349 | 7.82*** |
| | Urban/rural | .247 | .65 |
| | Sex | .302 | .78 |
| | Treatment | 1.078 | 2.93** |
| I-3 | Constant | −2.860 | |
| | Pretest | .312 | 6.52*** |
| | Urban/rural | .524 | 1.19 |
| | Sex | .207 | .48 |
| | Treatment | 1.726 | 3.97*** |
| I-4 | Constant | −2.885 | |
| | Pretest | .288 | 6.58*** |
| | Urban/rural | .770 | 2.02* |
| | Sex | −.205 | −.56 |
| | Treatment | 3.491 | |

* $p < .05$
** $p < .01$
*** $p < .001$

To summarize, the following conclusions can be drawn from the basic regression analyses:

1. Students participating in the experimental program score higher on all posttest forms than do control students.
2. Students with higher initial ability (as measured by pretest scores) score higher on all posttest forms.
3. Students in urban classrooms generally score higher on posttest than students in rural classrooms.
4. There are no appreciable differences attributable to sex in posttest achievement.

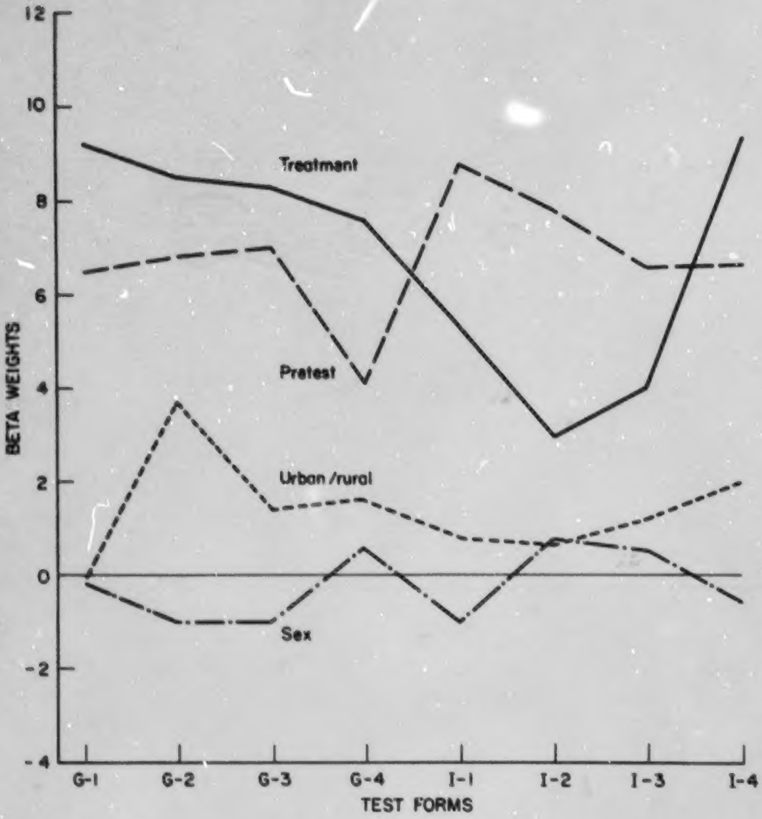

FIGURE 2. Regression beta weights plotted across G and I test forms.

The actual magnitudes of effects can be judged from the values of the regression coefficients in Tables 6 and 7. For example, the effect of the radio instructional program is to raise posttest scores roughly three items for G forms and form **I–4**, almost two items for forms **I–1** and **I–3**, and about one item for form **I–2**.

The multiple regressions estimate only linear effects of the factors; additional questions concerning possible nonlinear and interactive effects were answered by an examination of regression residuals, defined as the differences between predicted and observed posttest scores. Evidence was sought for nonlinear effects of both pretest

TABLE 8

Mean Regression Residuals for Treatment by Urban/Rural Interaction

| Test forms | | Control | Experimental | *F* | *df* |
|---|---|---|---|---|---|
| G | | | | .283* | 1, 654 |
| | Urban | .0949 | −.0989 | | |
| | Rural | −.0682 | .0520 | | |
| I | | | | .263* | 1, 654 |
| | Urban | −.1000 | .1040 | | |
| | Rural | .0719 | −.0549 | | |
| G & I | | | | | |
| | Urban | −.0027 | .0027 | | |
| | Rural | .0019 | −.0015 | | |

*$p > .05$

scores and interactions of treatment with pretest and urban/rural.

**Treatment-by-urban/rural interaction.** Table 8 presents an analysis of treatment-by-urban/rural interactions for **G** and **I** test forms. If there is no interaction, then the expected values of the mean residuals are zero and the variance of the mean residuals should be predicted by the within-cell variances. An approximate *F*-ratio statistic can be obtained for each table of residuals by calculating the variance of the means, multiplying by the harmonic mean number of residuals in each cell, and dividing by a weighted average of within-cell variances. This *F* statistic can be used to judge the magnitude of any interactive effect; for the numbers of observations and interaction degrees of freedom in Table 8, values of *F* greater than 3.84 should be considered significantly large ($p < .05$).

Table 8 shows that the interactions for **G** and **I** forms are in opposite directions and neither *F* statistic is large. These results indicate that the experimental program affects posttest achievement equally for both urban and rural students.

**Differences within the experimental group.** Within the experimental group, classrooms differed with respect to the degree of participation in the experimental program. Some classrooms were judged by project staff to have used the radio broadcasts less frequently than others. Furthermore, some classrooms were used in the weekly testing program. Taking these factors into account, three groups were identified as follows:

1. Low use—irregular use of radio broadcasts and supplementary project materials (11 classrooms);

2. Regular use—use of radio broadcasts as intended by the project (11 classrooms);
3. Weekly testing—regular use with supplementary testing (8 classrooms).

Since the effect of the experimental program was to raise posttest scores, it would be expected that regular use would raise scores more than irregular use. Also, test-taking experience would be expected to improve posttest scores, so that the weekly testing group would be expected to do better than the regular use group.

Table 9 presents mean residuals and approximate $F$-ratio statistics for **G** and **I** test forms. For **I** test forms the mean residuals indicate effects in the expected direction, with the weekly-testing group doing better than predicted by the regression and the low-use group doing worse than predicted, with the regular-use group in between. The $F$ statistic for the **I** test forms is significant ($p < .05$). For **G** test forms the weekly-testing group does better than predicted, while both the low-use and the regular-use groups perform about as predicted. The magnitude of the $F$ statistic is not significant here. Note that the magnitudes of the mean residuals range from .028 to .446 compared with a main effect of treatment on the order of from 1.0 to 3.0 items, so that conclusions about the impact of the experimental program are not substantially modified by consideration of variations within the experimental group.

TABLE 9

Mean Regression Residuals for Treatment Subgroups

| Test forms | | Mean residual | *N* | *F* | *df* |
|---|---|---|---|---|---|
| G | | | | | |
| | Low use | .089 | 120 | | |
| | Regular use | .093 | 132 | 1.04 | 2, 351 |
| | Weekly testing | −.224 | 102 | | |
| I | | | | | |
| | Low use | .446 | 120 | | |
| | Regular use | −.149 | 132 | 3.48* | 2, 351 |
| | Weekly testing | −.332 | 102 | | |
| G & I | | | | | |
| | Low use | .267 | 240 | | |
| | Regular use | −.028 | 264 | | |
| | Weekly testing | −.278 | 204 | | |

*$p < .05$

### *Item Analysis of Posttest*

We turn now to an examination of performance on the topics that comprise the first-grade curriculum. Posttest item scores for experimental and control students are presented in Table B of Appendix A. The results are summarized in Table 10. The mean item score for the experimental group (65.6%) is approximately 25 percentage points higher than the mean score for the control group. These results are for all children who were posttested.

The comparison of scores by topic for experimental and control students, presented in Table 11, indicates that the experimental students score consistently higher on all topics except geometry. The results for three topics require special mention. These three—basic concepts, geometry, and multiplication—were not taught by the radio lessons. The "basic concepts" topic includes comparisons of size (which is taller, shorter, wider, narrower), weight (which is heavier, lighter), and so on. The pretest results indicated that entering first-grade students knew these concepts quite well and therefore further practice was not included in the instructional program. Multiplication was not taught because the project staff thought the topic too difficult for first-grade students. The small amount of geometry required for first grade was difficult to teach by radio and was left to the teachers.

The radio lessons seem to be especially successful with oral topics—oral addition, oral subtraction, and oral word problems. For these three topics the difference between experimental and control groups is greater than 30 percentage points. This result is not surprising, since the radio instructional program gives heavy emphasis to oral presentations, but we feel it is of particular importance in a setting, such as rural Nicaragua, where most transactions are oral.

TABLE 10

Descriptive Statistics for 1976 First-grade Posttest

| Descriptor | Experimental | Control |
|---|---|---|
| Number of classes | 30 | 23 |
| Number of students | 571 | 438 |
| Number of test items | 84 | 84 |
| Mean item score (% correct) | 65.6 | 40.6 |
| Standard deviation | 19.9 | 18.9 |
| 95% confidence interval about mean | 61.3–70.0 | 36.5–44.7 |

TABLE 11

Comparison of 1976 First-grade Posttest Scores of Experimental and Control Students by Topic

| Topic | Number of items | Mean percentage correct | | |
|---|---|---|---|---|
| | | Experimental | Control | Difference |
| Numeration | 22 | 63.2 | 46.5 | 16.7 |
| Fractions | 4 | 78.5 | 32.5 | 46.0 |
| Oral addition | 6 | 73.4 | 35.8 | 37.6 |
| Vertical addition | 9 | 61.4 | 42.8 | 18.6 |
| Horizontal addition | 6 | 62.1 | 32.5 | 29.6 |
| Oral subtraction | 4 | 67.4 | 28.8 | 38.6 |
| Vertical subtraction | 9 | 47.0 | 22.6 | 24.4 |
| Horizontal subtraction | 3 | 48.8 | 22.5 | 26.3 |
| Money | 7 | 71.6 | 51.2 | 20.4 |
| Time | 1 | 68.1 | 14.7 | 53.4 |
| Length | 1 | 85.4 | 56.4 | 29.0 |
| Oral problems | 6 | 83.7 | 52.7 | 31.0 |
| Basic concepts | 3 | 86.6 | 64.6 | 22.0 |
| Geometry | 1 | 66.5 | 79.1 | −12.6 |
| Multiplication | 2 | 29.6 | 27.8 | 1.8 |

## 7. CONCLUSION

We summarize here some of the more salient aspects of this study. First, the experimental program was implemented without support from project staff in Nicaragua beyond the preparation and distribution of materials. Teachers were unsupervised, although they probably felt an obligation to use the radio lessons because they had been directed to do so by their School Inspectors. Second, the mean posttest item score for the experimental group was approximately 25 percentage points higher than the mean item score for the control group. This difference was highly significant ($p < .001$) both before and after adjusting the means of the two groups for effects of pretest and urban/rural classrooms. Third, regressions of posttest scores on several independent variables indicated highly significant effects of the treatment variable and pretest score, a significant effect of urban/rural classrooms, but no significant effect of the sex of the student.

Thus, it seems reasonable to conclude that the Radio Mathematics Program provides effective instruction in the experimental schools in Nicaragua.

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# APPENDIX A

## PRETEST AND POSTTEST SCORES FOR EXPERIMENTAL AND CONTROL STUDENTS

### TABLE A

Performance of Experimental and Control Students on TOBE, 1976 Administration

| Item number | Item text | Percentage correct | |
|---|---|---|---|
| | | Experimental | Control |
| 1 | "Mark the bottle that is empty" | 84.3 | 72.3 |
| 2 | "Mark the square that has the most bottles" | 92.7 | 86.9 |
| 3 | "Mark the figure that is pointed" | 94.4 | 91.3 |
| 4 | "Mark the straight line" | 86.4 | 78.9 |
| 5 | "Mark the square that has less than three figures" | 59.3 | 54.3 |
| 6 | "Mark the square that has only round things" | 74.9 | 70.7 |
| 7 | "Mark the figure that has two equal parts" | 48.0 | 45.7 |
| 8 | "Mark the cake that has four candles" | 93.3 | 86.7 |
| 9 | "Mark the square that has a pair of shoes" | 81.2 | 79.4 |
| 10 | "Mark the clock that has both hands up" | 57.8 | 55.3 |
| 11 | "Mark the figure that has corners" | 66.4 | 66.5 |
| 12 | "Mark the square that has six things" | 89.4 | 87.4 |
| 13 | "Mark the one that can carry the most" | 79.6 | 78.9 |
| 14 | "Mark the square with the most small balls" | 83.6 | 83.7 |
| 15 | "Mark the clock with the large hand" | 92.5 | 87.2 |
| 16 | "Mark the square with the coins that are equal" | 47.3 | 51.8 |
| 17 | "Mark the number three" | 91.4 | 87.2 |
| 18 | "Mark the ruler" | 78.9 | 78.0 |
| 19 | "Mark the fruit that is whole" | 87.6 | 86.5 |
| 20 | "Mark the square where all the fruit is the same size" | 71.7 | 76.4 |
| 21 | "Mark the square that has six baseballs" | 71.7 | 72.9 |
| 22 | "Mark the boy that weighs the most" | 96.6 | 94.3 |
| 23 | "Mark the square that has three balls on each side of the line" | 57.8 | 59.6 |
| 24 | "Mark the second rooster" | 48.9 | 42.9 |
| 25 | "Mark the longest rope" | 43.4 | 46.8 |
| 26 | "Mark the biggest coin" | 92.2 | 89.2 |
| 27 | "Mark the bottle that has the most beans" | 88.1 | 85.8 |
| 28 | "Mark the fruit that is cut in half" | 32.8 | 31.6 |

TABLE B

Performance of Experimental and Control Students on 1976 First-grade Achievement Test

| Item[a] | Percentage correct | | Description of exercise |
|---|---|---|---|
| | Experimental | Control | |
| 1–A | 95.6 | 72.5 | Circle the figure that has the most buttons (8, 12, 10) |
| 1–B | 84.1 | 67.9 | Write the number 42 |
| 1–C | 79.6 | 31.7 | Oral subtraction 5 − 1 |
| 1–D | 89.0 | 79.8 | Circle the widest bench (2 choices) |
| 2–A | 83.0 | 54.1 | What number comes after 13 |
| 2–B | 86.5 | 27.6 | Circle the fraction one-half (1/4, 2/3, 1/2, 1/3) |
| 2–C | 75.2 | 41.6 | Circle the figure that has fewest buttons (10, 12, 8) |
| 2–D | 97.6 | 34.0 | Oral word problem 5 + 5 |
| 3–A | 98.4 | 78.9 | Circle the 50-cent coin |
| 3–B | 81.2 | 73.1 | Circle the third boy (in a line) |
| 3–C | 92.0 | 64.4 | Circle the number eighty-two (28, 82, 72, 7) |
| 3–D | 86.6 | 39.4 | Circle the figure divided into halves |
| 4–A | 88.5 | 69.7 | Oral word problem 8 − 2 |
| 4–B | 74.7 | 29.9 | Oral addition 2 + 5 |
| 4–C | 90.5 | 62.4 | Count the men without hats (3 with, 5 without) |
| 4–D | 78.1 | 37.2 | Oral addition 7 + 4 |
| 5–A | 68.7 | 32.1 | Circle the figure divided into fourths |
| 5–B | 97.1 | 85.8 | Circle the 5-córdoba bill (3 choices) |
| 5–C | 78.1 | 38.6 | Oral word problem 3 + 6 |
| 5–D | 52.4 | 30.9 | Circle the smallest number (41, 38, 36) |
| 6–A | 91.8 | 66.1 | Oral word problem 6 − 4 |
| 6–B | 52.4 | 38.8 | Write the number that comes before 14 |
| 6–C | 95.6 | 70.3 | Circle the 50-córdoba bill |
| 6–D | 79.3 | 41.5 | Oral addition 30 + 4 |
| 7–A | 69.8 | 48.6 | Write the number that comes after 85 |

(TABLE B, cont.)

| Item[a] | Percentage correct | | Description of exercise |
|---|---|---|---|
| | Experimental | Control | |
| 7-B | 61.8 | 33.6 | 5+7 = ____ |
| 7-C | 70.1 | 34.7 | Oral addition 23+1 |
| 7-D | 42.7 | 34.0 | Write the number that comes after 59 |
| 8-A | 72.5 | 53.2 | Circle the smallest (43, 47, 51) |
| 8-B | 70.0 | 28.4 | Oral addition 2+1+3 |
| 8-C | 72.3 | 30.7 | Circle the figure divided into thirds |
| 8-D | 48.8 | 21.3 | Write the number that comes before 40 |
| 9-A | 68.1 | 43.1 | Oral addition 8+7 |
| 9-B | 70.0 | 28.4 | Oral subtraction 9−4 |
| 9-C | 72.3 | 26.7 | Write the number that comes before 36 |
| 9-D | 48.8 | 62.8 | Circle the word "four" (3 choices) |
| 10-A | 68.1 | 14.7 | What time does the clock say? (8) |
| 10-B | 66.5 | 79.1 | Circle the triangle (3 choices) |
| 10-C | 58.4 | 30.7 | Write the word "eight" |
| 10-D | 85.4 | 56.4 | Measuring—pencil and cm ruler (8 cm) |
| 11-A | 61.0 | 32.1 | Oral subtraction 54−1 |
| 11-B | 58.2 | 38.8 | Oral word problem 3×3 |
| 11-C | 59.1 | 23.8 | Oral subtraction 45−5 |
| 11-D | 87.8 | 69.2 | Oral word problem 10−6 |
| 12-I | 53.7 | 47.3 | Count the balls (32) |
| 12-II | 61.4 | 51.4 | Count the balls (24) |
| 12-III | 73.6 | 59.4 | Count the balls (15) |
| 12-IV | 91.3 | 72.5 | Count the balls (7) |
| 13-I | 36.8 | 13.4 | How much money is shown? (50 cents, 10 cents, 5 cents) |
| 13-II | 46.2 | 45.1 | How much money is shown? (25 cents) |
| 13-III | 62.1 | 29.3 | How much money is shown? ($5, $1, $1, $1) |
| 13-IV | 64.7 | 35.8 | How much money is shown? ($5) |

(TABLE B, cont.)

| Item[a] | Percentage correct | | Description of exercise |
|---|---|---|---|
| | Experimental | Control | |
| 14–I | 13.2 | 18.8 | Fill in the missing number (4, 6, __, 10) |
| 14–II | 17.2 | 10.8 | Fill in the missing number (5, 10, __, 20) |
| 14–III | 59.3 | 46.2 | Fill in the missing number (50, 60, __, 80) |
| 14–IV | 72.0 | 46.8 | Fill in the missing number (83, 84, __, 86) |
| 15–I | 54.4 | 65.2 | 3<br>+2 |
| 15–II | 68.3 | 36.0 | 3+9 |
| 15–III | 52.1 | 58.5 | 3<br>+4 |
| 15–IV | 66.7 | 33.9 | 8+0 |
| 16–I | 54.4 | 26.8 | 8<br>−6 |
| 16–II | 68.3 | 43.2 | 9<br>−0 |
| 16–III | 52.1 | 36.8 | 7−3 |
| 16–IV | 66.7 | 12.8 | 4−4 |
| 17–I | 75.0 | 59.8 | 5<br>2<br>+2 |
| 17–II | 42.8 | 28.8 | 64+1 |
| 17–III | 72.1 | 54.7 | 6<br>+5 |
| 17–IV | 72.0 | 32.1 | 1+4+3 |

(TABLE B, cont.)

| Item[a] | Percentage correct | | Description of exercise |
|---|---|---|---|
| | Experimental | Control | |
| 18–I | 61.8 | 16.1 | 25<br>+3 |
| *18–II | 27.6 | 18.0 | 14−7 |
| *18–III | 7.1 | 16.0 | 13<br>−9 |
| 18–IV | 60.7 | 30.3 | 90+5 |
| 19–I | 62.5 | 38.4 | 16<br>+32 |
| 19–II | 40.0 | 20.7 | 96<br>−72 |
| 19–III | 47.1 | 28.3 | 35<br>−13 |
| 19–IV | 65.3 | 34.9 | 41<br>+36 |
| *20–I | 30.1 | 26.8 | 5<br>×2 |
| *20–II | 29.0 | 28.8 | 4×2 |
| 20–III | 47.9 | 12.3 | 53<br>−2 |
| 20–IV | 55.3 | 10.1 | 68<br>−5 |
| 21–I | 50.0 | 30.4 | 56<br>−36 |
| 21–II | 47.6 | 34.2 | 32<br>15<br>+50 |

(TABLE B, cont.)

| Item[a] | Percentage correct | | Description of exercise |
|---|---|---|---|
| | Experimental | Control | |
| 21–III | 62.1 | 23.6 | $\begin{array}{r} 35 \\ \underline{+40} \end{array}$ |
| 21–IV | 53.3 | 15.6 | $\begin{array}{r} 67 \\ \underline{-20} \end{array}$ |

[a] Starred items were not taught by RMP curriculum. Items labeled A–D are G items, those labeled I–IV are I items.

## *Chapter 4*

# WEEKLY TESTS

KLAUS GALDA
AND
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THE Radio Mathematics Program has two principal mechanisms for gathering information about how well the children are following the lessons: daily classroom observations and weekly tests. Classroom observations provide valuable feedback on how the lessons are being received and understood. They generally give the observer a more direct and intuitive understanding of what is happening in the classroom than can be obtained from abstract data. Weekly tests, on the other hand, provide more precise data on levels of student performance and allow charting of student progress in a systematic way. In addition, analysis of student errors helps us to identify probable causes of error. We estimate that we are able to diagnose student difficulties in about half the cases and this information is used in designing future lessons to help students avoid common pitfalls.

## 1. ADMINISTRATION OF TESTS

Weekly tests are administered during the year that lessons for a particular grade level are under development. The schools participating in the weekly testing program are chosen to satisfy two criteria:

1. There are equal numbers of urban and rural schools.
2. Locations are convenient to the project office.

One classroom is tested in each school. This chapter reports on the 1977 testing program. Twelve third-grade classes, six from rural schools and six from urban schools, were used in the testing program. Four of the six classes from each location had used the radio program in second grade in 1976. All 12 classes were tested each week from the

6th to the 30th week of school. An attempt was made to test each class on the same day of the week.

The tests, which take about 20 minutes, were administered each week by a project staff member, who visited the classroom at a time other than during the mathematics lesson (chosen after consultation with the teacher). At the beginning of the testing session answer sheets and pencils (if necessary) were distributed. The staff member then read the exercises or instructions aloud and paced the test according to the speed of the children's responses.

## 2. CONSTRUCTION OF TESTS

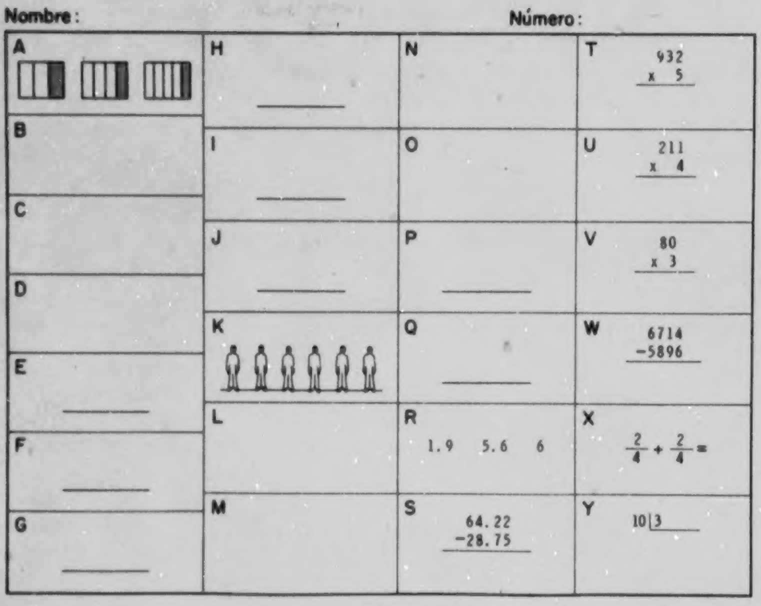
All of the tests use a multiple matrix sampling design. As described in chapter 3, items are of two types, referred to as **G** ("group") and **I** ("individual") items. Approximately the first half of the exercises are **G** items. In Figure 1, which is the answer sheet for a third-grade weekly test, items A through Q are **G** items and R through Y are **I** items.

**G** items are identical for all students in a classroom and each such exercise is read aloud to the students. In some exercises the students are asked to write only the answer. For example, item A in Figure 1 might be the exercise "Circle the figure that is divided into fourths." In others, the student writes both the exercise and the answer. For example, the test administrator might dictate the exercise "257 plus 376" and ask the children to carry out the addition, putting all their work in the answer space labeled B.

The printed displays accompanying an **I** item are different on the answer sheets distributed within a classroom; oral instructions, when they are necessary, are appropriate for all such displays. For example, the instruction for item R in Figure 1 might be "Circle the largest number." Approximately one-fourth of the children have answer sheets with the display shown in Figure 1; other answer sheets have other displays—that is, other sets of numbers—for which the same instruction is appropriate. For items S through Y, which are also **I** items and therefore differ on different answer sheets, the students are simply asked to finish working the exercises and are given as much time as they need.

### *Selection of Topics to Be Tested*

We turn now to the problem of how items are chosen for weekly tests. As discussed in chapter 2, the year's curriculum is based on the specifications of the Ministry of Public Education, and the content is divided into conceptually distinct strands. Each strand is then divided



Nombre:

Número:

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R 1.9 5.6 6

S $64.22 - 28.75$

T $932 \times 5$

U $211 \times 4$

V $80 \times 3$

W $6714 - 5896$

X $\frac{2}{4} + \frac{2}{4} =$

Y $10\overline{)3}$

FIGURE 1. Answer sheet for third-grade weekly test.

into *classes* of exercises, each of which is explicitly defined by the characteristics of the exercise and the type of response asked for. The weekly tests are designed to provide performance data on these classes of exercises. We choose a subset (rather than all) of the exercise classes for weekly testing for the following reasons:

1. There are too many classes in the curriculum to allow testing each class an adequate number of times.
2. Some of the classes do not lend themselves to group testing; for example, none of the classes of exercises requiring oral responses is tested.
3. The concepts involved in some of the classes are tested just as well by testing other classes. For example, the addition classes AV7 and AV8 differ only in the number of columns involved (see App. A) and performance on AV7 is a good indicator of performance on AV8, which is therefore not tested.
4. The performance level on some classes is so high (as indicated by pretest results or observational data) that little is to be learned by testing them.
5. There is no pragmatic reason for testing some exercise classes. For example, time or other limitations make it impossible to reteach some topics, no matter what the test results.

Using these criteria to eliminate many of the exercise classes, the remainder are then classified as containing **G** items or **I** items. The classes of **G** items are further divided into two types: dictation exercises, which require that the students write both the exercise and the solution, and oral exercises, which are either multiple choice or require a constructed response. Appendix A gives a breakdown of the different types of test classes used in the 1977 third-grade curriculum.

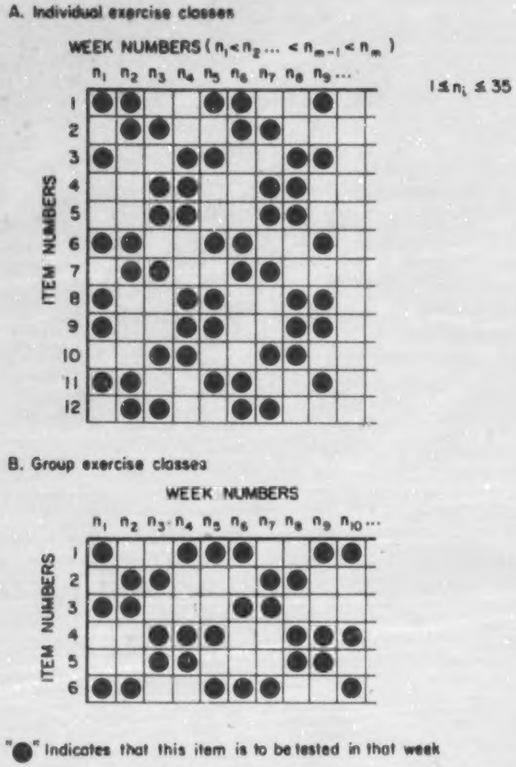
Since our interests and difficulties are constantly changing throughout the year in which we are producing the curriculum, we leave the choice of test classes until the week in which the test is to be given. The selection of classes to be tested in a given week is generally made according to the following guidelines:

1. If Class A is a key prerequisite for Class B (see chap. 2), then Class A should be tested about four weeks before Class B is scheduled to be taught. Then if the results of the test of Class A are low, the curriculum specialist may decide to postpone the teaching of Class B until A has been retaught and mastered.
2. If an exercise class is scheduled to be taught or reviewed in Week $n$ of the school year, then that class will be tested in Week $n-1$ or $n-2$. This serves as a small pretest to determine the performance level of the students immediately before being taught the concept.
3. Similarly, if teaching or review is scheduled to end in Week $m$, then that class will be tested in Week $m+1$. Curriculum decisions are then made on the basis of the test results. Poor performance on classes that are not key prerequisites may signal the need for reteaching even though the overall scheduling of instruction is not changed.
4. Other classes are chosen for various reasons. Often classes are tested several times in order to gather data on the principal causes of student errors.

### *Selection of Test Items*

The set of items used to determine performance levels on an exercise class is called a *test class*. These items are chosen before the first time the class is tested. The initial item pool is a large number of computer-generated exercises that satisfy the definition of the exercise class. From this large set of exercises the appropriate number of items is selected at random (with the restriction that no item occur more than once). For each class the number of items chosen is twice that needed to construct a weekly test. Since each test requires 6 **I** items and 3 **G** items, 12 and 6 items, respectively, are chosen. (Recall that **G** items are given to an entire classroom. Therefore, each **G** item is given to four classrooms.)

Although these items are all similar enough to belong to the same



A. Individual exercise classes

WEEK NUMBERS ($n_1 < n_2 \ldots < n_{m-1} < n_m$)

$1 \leq n_i \leq 35$

ITEM NUMBERS

|  | $n_1$ | $n_2$ | $n_3$ | $n_4$ | $n_5$ | $n_6$ | $n_7$ | $n_8$ | $n_9$ | … |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ● | ● |  |  | ● | ● |  |  | ● |  |
| 2 |  | ● | ● |  |  | ● | ● |  |  |  |
| 3 | ● |  |  | ● | ● |  |  | ● | ● |  |
| 4 |  |  | ● | ● |  |  | ● | ● |  |  |
| 5 |  |  | ● | ● |  |  | ● | ● |  |  |
| 6 | ● | ● |  |  | ● | ● |  |  | ● |  |
| 7 |  | ● | ● |  |  | ● | ● |  |  |  |
| 8 | ● |  |  | ● | ● |  |  | ● | ● |  |
| 9 | ● |  |  | ● | ● |  |  | ● | ● |  |
| 10 |  |  | ● | ● |  |  | ● | ● |  |  |
| 11 | ● | ● |  |  | ● | ● |  |  | ● |  |
| 12 |  | ● | ● |  |  | ● | ● |  |  |  |

B. Group exercise classes

WEEK NUMBERS

ITEM NUMBERS

|  | $n_1$ | $n_2$ | $n_3$ | $n_4$ | $n_5$ | $n_6$ | $n_7$ | $n_8$ | $n_9$ | $n_{10}$ … |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ● |  |  | ● | ● | ● |  |  | ● | ● |
| 2 |  | ● | ● |  |  |  | ● | ● |  |  |
| 3 | ● | ● |  |  |  | ● | ● |  |  |  |
| 4 |  |  | ● | ● | ● |  |  | ● | ● | ● |
| 5 |  |  | ● | ● |  |  |  | ● | ● |  |
| 6 | ● | ● |  |  | ● | ● | ● |  |  | ● |

"●" Indicates that this item is to be tested in that week

FIGURE 2. Algorithms for selection of items for weekly tests.

test class, there are in fact differences among them. Within each class we order the items by our estimate of their relative difficulty; thus the **I** items are ordered 1–12 and the **G** items 1–6. Test items for the week are then chosen according to the fixed algorithms shown in Figure 2.

These algorithms have several desirable features. If our ordering of the difficulty of the items within a test class is approximately correct, then they guarantee that in any given week the average difficulty of the test items used is about the same. Another feature is that about half of the items included also appeared the last time that this particular class was tested, making it possible to ascertain more exactly the progress that has been made with this particular type of exercise in the intervening weeks. In addition to simply ordering the items within a test class, we often divide them into two or three groups according to the different exercise types within the test class. With the above algorithms we have a fairly even distribution of exercise types on any given weekly test.

From the preceding description of the selection process for the exercises on a weekly test it can be seen that

1. Most of the test classes chosen for a particular week are determined by the structure of the curriculum.
2. In any week some of the test classes can also be chosen specifically to provide more precise feedback on the students' performance, to improve future lessons.
3. Within a given test class the actual items chosen for a particular week are determined by a fixed algorithm. (Occasionally this rule is not strictly followed, since at times we may want to select particular items in order to test certain hypotheses about student errors.)

## 3. EXAMPLES FROM TWO TEST CLASSES

In order to clarify some of the ideas presented here we will select two test classes and follow their testing history through the school year. For the first example let us look at the exercise class SV17 ("SV" stands for "vertical subtraction"). This is a class of subtraction exercises of the form

$$\begin{array}{r} \mathrm{a10b} \\ \underline{-\mathrm{cdef}} \end{array}$$

where $0 \leq b < f$ and $a > 0$.[1] In these exercises the student must borrow from the 10 in the minuend. The exercises in the test class are shown in Table 1. The test items for SV17 are **I** items; thus there should be 12 exercises from which 6 are chosen for each test. (Because of an oversight there are only 11 exercises and only 5 were tested in Weeks 11 and 33.) The class is divided into two subclasses that reflect the levels of difficulty. In the first subclass of eight items the last digit in the minuend, b, is greater than zero; in the second subclass of three items it is zero. The second subclass is more difficult.

SV17 was first tested in Week 11 of the school year (see Table 1). At that time the children had not learned to borrow from either 0 or 1, and the average percentage correct in that week was only about 4; in fact there was not a single correct answer on the items with minuend 100. In Week 17 we tested this class again. The specific computation skill involved in SV17 had not been taught yet, but in Weeks 15 and 16 we had taught the children how to borrow from

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[1] In describing exercises, a lowercase letter stands for a single digit that is in the range 0 to 9 unless otherwise specified.

TABLE 1
Test Results for SV17

| Item | Percentage correct | | | | | |
|---|---|---|---|---|---|---|
| | Week of test | | | | | |
| | 11 | 17 | 19 | 23 | 26 | 29 |
| 2105<br>− 48 | | 17 | | 59 | 63 | 67 |
| 6102<br>− 45 | | | 22 | | | 77 |
| 6105<br>−2046 | | | 29 | | 58 | |
| 7102<br>− 33 | | 34 | | | | |
| 7105<br>−2018 | 7 | | | 57 | | |
| 8106<br>− 39 | 4 | | 13 | 51 | 55 | 67 |
| 4102<br>−1039 | 11 | 21 | | 53 | | 70 |
| 8107<br>−2019 | | 28 | | | 59 | |
| 5100<br>−4025 | 0 | 14 | 15 | 36 | 41 | |
| 6100<br>−6025 | | | 14 | | 50 | 58 |
| 4100<br>−4086 | 0 | 22 | 23 | | | 42 |
| Mean for test | 4 | 23 | 19 | 51 | 54 | 64 |

minuends of the form a1bc and ab0c. We expected some of the children to transfer this knowledge to exercises combining these two skills. In fact, the average percentage correct did jump significantly to 23. In Week 19 there was not much change, nor any particular reason to expect any. However, this was the last time the class SV17 was tested before it was scheduled to be taught in Week 22. Immediately after it had been taught there was a sharp increase to 51% in Week 23. On the next test, given in Week 26, the results leveled off. In Weeks 27 and 28 the lessons contained more exercises of this type and the performance level increased to 64% in the Week-29 test. The pattern of results displayed here is typical for an exercise class that shows a very low initial performance level and for which teaching is relatively successful. (Although a performance level of 64% may seem low to the reader, these exercises are typically very difficult, and an increase from 4% to 64% is quite substantial.)

Let us take a brief look at one more example. This is the class MO4 ("oral multiplication") with exercises of the form a × 0 with $0 \leq a \leq 9$. The six exercises in the test class are shown in Table 2. They are **G** items; the items are read aloud and the student writes only the answer. As shown in Table 2, in Weeks 8 and 11 the test results were consistently low—19%. In Week 14 we began to teach the concept and obtained immediate results with 79% on the test in

TABLE 2

Test Results for MO4

| Item | Percentage correct | | | | | |
|---|---|---|---|---|---|---|
| | Week of test | | | | | |
| | 8 | 11 | 15 | 17 | 21 | 25 |
| 1 × 0 | 24 | | | | | |
| 5 × 0 | 17 | 19 | | | 86 | 94 |
| 4 × 0 | | 30 | 72 | | 84 | 95 |
| 7 × 0 | | | 82 | | 62 | |
| 9 × 0 | | | 83 | 90 | | |
| 0 × 0 | | | | | | 95 |
| 3 × 0 | | | | 98 | | |
| 8 × 0 | 18 | 8 | | | | |
| 6 × 0 | | | | 98 | | |
| Mean for test | 19 | 19 | 79 | 96 | 77 | 95 |

Week 15. With additional practice the performance level climbed to 96% in Week 17. In Week 21 the class was tested again; the drop of almost 20 points to 77% was unexpected. We hypothesized that the drop was due to a series of exercises that mixed exercises of the type a × 0 = 0 with exercises of the type a + 0 = a. We therefore added some drill exercises of the form a × 0 and the performance level promptly rose again to 95% on the Week-25 test.

These examples have given a fairly detailed view of a small sample of the results we have obtained from the weekly testing program. They have also shown some of the ways in which we use the results to determine how effective our teaching of a particular type of exercise has been, and at the same time how the test results can be used to modify the curriculum. Generally the test results serve to indicate the weak points in the program and help us to decide in which areas the teaching method must be modified—sometimes to the point of completely abandoning an approach. This latter was the case with some of the curriculum material on mixed numbers in the third grade, which, as a result of both classroom observation and poor results on weekly tests, we decided to abandon and teach again in the fourth grade using a different approach.

At other times weekly tests have indicated that the children perform well on some types of exercises without their having been explicitly taught. For example, the third-grade curriculum was to include the concept of using division to solve simple partition problems like:

> John has 12 pencils. He wants to distribute them equally among his four friends. How many pencils should he give to each friend?

The performance level several weeks before the planned teaching of this problem type was 94% correct; we decided it was pointless to use valuable time to teach a concept that the children had apparently already learned.

High pretest scores occur much more frequently than we had anticipated. Figure 3 shows the distribution of mean scores for 37 test classes tested before teaching (from the 1976 second-grade curriculum). The scores ranged from 0% to 94% correct with a mean of 52.1% and, as the histogram shows, the most frequent scores were in the 40% to 60% range. For about one-sixth of the test classes the percentage correct was over 80. These results remind us that in designing curriculum one must take into account the prior knowledge of the children and that the level of prior knowledge is frequently quite high.

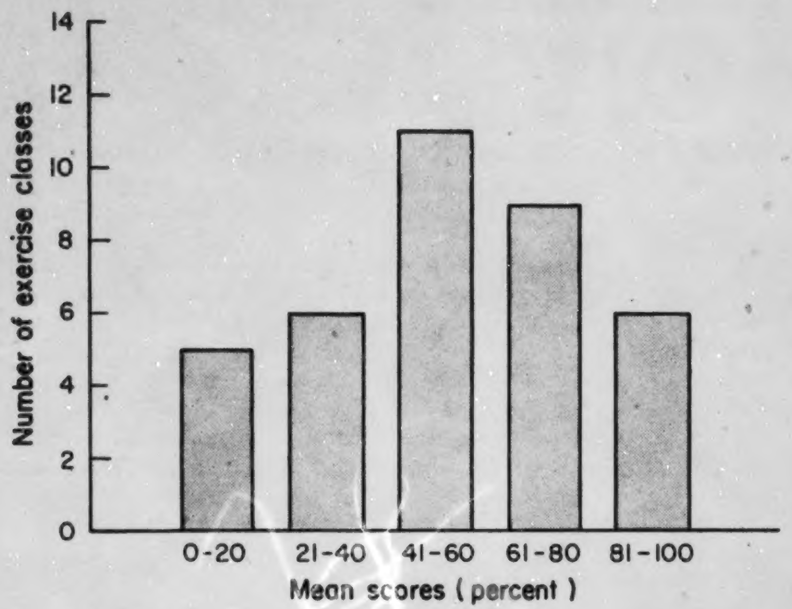

FIGURE 3. Distribution of scores on 37 exercise classes tested before teaching.

## 4. SUMMARY

The weekly testing program is an integral part of the feedback system for developing curriculum that has been described earlier in this volume. Although some of the details of implementation change from year to year, the basic structure of the program remains the same. The testing program is used only in the year the curriculum is being developed. In 1977 the program involved about 300 children; the number of responses to each **I** item was about 50, to each **G** item, about 100. Each class of exercises is tested several times during the course of the school year—at least once long before it is to be taught, once immediately before it is to be taught, once immediately after it has been taught, and once more at a later time to see whether performance level after teaching has been maintained. These test results provide an extensive record of the progress of the children for most of the concepts that are included in the curriculum. Often the results merely confirm what we expected to happen; sometimes, however, there are genuine surprises that guide us in modifying the curriculum.

# APPENDIX A

Test Classes used in 1977 Third-grade Weekly Tests

| Class name | Type | Description |
|---|---|---|
| NC4 | I | Printed picture of several boxes with 10 balls in each box. Student counts number of balls. |
| NE2a | G | Number of type a00 dictated. Student writes number. |
| NE2c | I | Number of type a00 printed. Student writes name of that number. |
| NE3a | G | Number of type a0b ($1 \leq a, b \leq 9$) dictated. Student writes number. |
| NE3b | G | 3 numbers printed. Student circles a number a0b given orally. |
| NE3c | I | Number of type a0b printed. Student writes name of that number. |
| NE4a | G | Number of type a000 dictated. Student writes that number. |
| NE4b | G | 3 numbers printed. Student circles a number a000 given orally. |
| NE4c | I | Number of type a000 printed. Student writes name of that number. |
| NE5a | G | 4 digit number without zeros given orally. Student writes number. |
| NE5b | G | 3 numbers printed. Student circles 4 digit number given orally. |
| NE5c | I | 4 digit number without zeros printed. Student writes name of that number. |
| NE6a | G | 4 digit number with 1 or 2 zeros given orally. Student writes number. |
| NE6b | G | 3 numbers printed. Student circles 4 digit number with 1 or 2 zeros given orally. |
| NE6c | I | 4 digit number with 1 or 2 zeros printed. Student writes name of that number. |
| NE8 | I | 4 or 5 digit number printed. Student puts in comma. |
| NE11a | I | Integer containing zeros (some necessary, others not) printed. Student crosses out unnecessary zeros. |
| NE11b | I | Integer with unnecessary zeros printed. Student writes name of that integer. |
| NO1 | G | Line of soldiers printed. Student circles nth soldier ($1 \leq n \leq 6$). |
| NO3 | G | Line of soldiers printed. Student circles nth soldier ($7 \leq n \leq 12$). |
| NF1a | G | 3 figures representing fractions printed. Student circles figure representing the fraction given orally. |

| Class name | Type | Description |
|---|---|---|
| NF1b | G | Empty rectangle printed. Student fills in rectangle to represent a fraction given orally. |
| NF3a | G | Fraction a/b ($1 \leq a, b \leq 5$, and $a \leq b$) is printed. Student writes fraction. |
| NF3c | I | Fraction a/b ($1 \leq a, b \leq 5$, and $a \leq b$) is printed. Student writes name of fraction. |
| NF3e | I | 3 fractions and a figure representing one of them printed. Student circles correct choice. |
| NF4a | G | Fraction a/b ($a \leq b$, $6 \leq b \leq 10$ or $b = 100$) given orally. Student writes fraction. |
| NF4b | G | 3 fractions printed. Student circles fraction a/b ($a \leq b$, $6 \leq b \leq 10$ or $b = 100$) given orally. |
| NF4c | I | Fraction a/b ($a \leq b$, $6 \leq b \leq 10$ or $b = 100$) printed. Student writes name of fraction. |
| NF5a | G | Mixed number a b/c given orally. Student writes number. |
| NF5c | I | Figure representing mixed number and 3 choices printed. Student circles number represented by the figure. |
| NF5d | G | Mixed number given orally. Student draws a figure representing that mixed number. |
| ND1a | G | Decimal a.b ($1 \leq a, b \leq 9$) given orally. Student writes decimal. |
| ND1b | G | 3 numbers printed. Student circles number a.b ($a \leq b$, $b \leq 9$) given orally. |
| ND1c | I | Mixed number a b/10 printed. Student writes that number as a decimal. |
| ND1e | I | Decimal a.b printed. Student writes name of decimal. |
| ND2 | G | Decimal a.bc ($1 \leq a,b,c \leq 9$) given orally. Student writes decimal. |
| ND3a | G | Decimal .a ($1 \leq a \leq 9$) given orally. Student writes decimal. |
| ND3b | G | 3 numbers printed. Student circles number .a given orally. |
| ND3c | I | Fraction a/10 ($1 \leq a \leq 9$) printed. Student writes that fraction in decimal form. |
| ND3d | I | Decimal .a printed. Student writes that decimal as a fraction. |
| ND3e | I | Decimal .a printed. Student writes name of that decimal. |
| CE5a | I | 3 integers (1 or 2 digits) printed. Student circles largest. |
| CE5b | I | 3 integers (1 or 2 digits) printed. Student circles smallest. |
| CE9a | I | 3 integers (up to 3 digits) printed. Student circles largest. |
| CE9b | I | 3 integers (up to 3 digits) printed. Student circles smallest. |
| CE10 | I | 3 integers (4 digits) printed. Student circles largest. |

| Class name | Type | Description |
|---|---|---|
| CE11 | I | 3 integers (4 digits with zeros) printed. Student circles largest. |
| CE12 | I | 3 integers (up to 3 digits, with zeros) printed. Student circles largest. |
| CF1a | I | 3 fractions, a/d, b/d, c/d ($a,b,c \le d \le 9$) printed. Student circles largest fraction. |
| CF2a | I | 2 fractions 1/a, 1/b ($a,b \le 9$) printed. Student circles largest fraction. |
| CF2b | I | 3 fractions 1/a, 1/b, 1/c ($a,b,c \le 100$) printed. Student circles largest fraction. |
| CF3 | I | 3 numbers (integers and proper fractions) printed. Student circles largest number. |
| CF5 | I | 'a cakes, b cakes, c cakes' (a,b,c either integers or fractions) printed. Student circles largest quantity. |
| CF6 | I | 2 mixed numbers printed. Student circles largest number. |
| CD2a | I | 3 decimals a.b ($1 \le a, b \le 9$) printed. Student circles largest number. |
| CD3 | I | 3 numbers (integers and decimals a.b) printed. Student circles largest number. |
| CD6 | I | 3 decimals a.bc ($1 \le a, b \le 9, 0 \le c \le 9$) printed. Student circles largest number. |
| AO3 | G | Addition exercise a0 + b0 ($a + b \le 9$) given orally. Student writes answer. |
| AO4 | G | Addition exercise a + b + c ($0 \le a,b,c \le 9$) given orally. Student writes answer. |
| AO5 | G | Addition exercise ab + c or c + ab ($1 \le a,b,c \le 9$) given orally. Student writes answer. |
| AO6 | G | Addition exercise ab + c0 ≤ 99 ($1 \le a,b,c \le 9$) given orally. Student writes answer. |
| AO7 | G | Addition exercise ab + cd ≤ 99 ($1 \le a,b,c,d \le 9$; $b + d \le 9$) given orally. Student writes answer. |
| AV2 | I | Student solves printed addition exercise with 2 addends of 3 columns or 2 numbers of 4 columns, no carrying, no passing. (Sum in leftmost column is greater than 1.) |
| AV3a | I | Student solves printed exercise ab + c or c + ab ($c + b \le 9$). |
| AV3b | G | Addition exercise ab + c or c + ab ($c + b \le 9$) given orally. Student writes both exercise and answer. |
| AV4a | I | Student solves printed addition exercise with 2 addends, no carrying, no passing; one addend has 3 or 4 columns, the other has fewer columns. |
| AV4b | G | Exercise of type AV4a given orally. Student writes both exercise and answer. |

| Class name | Type | Description |
|---|---|---|
| AV7a | I | Student solves printed addition exercise with 3 or 4 addends; each addend with 1 or 2 columns, passing, but no carrying. |
| AV7b | G | Exercise of type AV7a given orally. Student writes both exercise and answer. |
| AV10 | I | Student solves printed addition exercise with 2 addends, 1 carry; both addends have same number of columns (2, 3, or 4). |
| AV11a | I | Student solves addition exercise with 1 carry, varying number of addends and columns (2, 3, or 4). |
| AV11b | G | Exercises of type AV11a given orally. Student writes both exercise and answer. |
| AV12 | I | Student solves printed addition exercise. 2 addends with same number of columns (3 or 4), 2 carries. |
| AV14 | I | Student solves printed addition exercise. 3 or 4 addends with varying number of columns (1 or 2), 2 or 3 carries. |
| AV15 | I | Student solves printed addition exercise, 3 or 4 addends with varying number of columns (1, 2, or 3), 2 carries. |
| AV16a | I | Student solves printed decimal addition exercise ($a.b + c.d$ or $.a + .b$), no carry. |
| AV16b | G | Exercise of type AV16a given orally. Student writes both exercise and answer. |
| AV19 | I | Student solves printed decimal addition exercise, 2 addends, same number of columns (2–5), same number of columns after decimal (1 or 2), up to 3 carries. |
| AV22 | I | Student solves printed decimal addition exercise, 2 addends, varying number of columns before and after decimal (1 or 2 each), no carries. |
| AV24 | I | Student solves printed decimal addition exercise, 2 addends, one of them without decimal point, no carries. |
| AF1a | G | Student solves horizontally printed fraction addition exercise, $a/b + b/c$; $a + b \leq c \leq 5$. |
| AF1b | G | Exercise of type AF1a given orally. Student writes both exercise and answer. |
| AF2a | I | Student solves horizontally printed fraction addition exercise, $a/c + b/c$, $a + b \leq c \leq 10$ or $a + b \leq c = 100$. |
| AF2b | G | Exercise of type AF2a given orally. Student writes both exercise and answer. |
| SO1 | G | Subtraction exercise $a - b$, $b < a \leq 10$, given orally. Student writes answer. |
| SO2 | G | Subtraction exercise $a - b$, $b < 10 < a$, $a - b < 10$ given orally. Student writes answer. |
| SO3 | G | Subtraction exercise $ab - 1$, $1 \leq a, b \leq 9$, given orally. Student writes answer. |

| Class name | Type | Description |
|---|---|---|
| SO4 | G | Subtraction exercise $a0 - 1$, $1 \le a \le 9$, given orally. Student writes answer. |
| SO7 | G | Subtraction exercise $a00 - 1$, $1 \le a \le 9$, given orally. Student writes answer. |
| SO8 | G | Subtraction exercise $ab - c$, $c \le b$, given orally. Student writes answer. |
| SO9 | G | Subtraction exercise $ab - a0$, given orally. Student writes answer. |
| SH6 | I | Student solves horizontally printed subtraction exercise $ab - c$ ($c \le b$). |
| SV2 | I | Student solves printed subtraction exercise, same number of columns (3 or 4), no borrowing, no zeros at the left of the answer. |
| SV3a | I | Student solves exercise of type SH6, printed vertically. |
| SV3b | G | Exercise of type SH6 given orally. Student writes it in vertical form and solves it. |
| SV6 | I | Student solves printed subtraction exercise, $abc - ade$ or $abcd - aef$, no borrowing. |
| SV8 | I | Student solves printed subtraction exercise, $ab - cd$, $b < d$. |
| SV9 | I | Student solves printed subtraction exercise, same number of columns (3 or 4), borrowing once. |
| SV10 | I | Student solves printed subtraction exercise, borrowing once, varying number of columns, or exercise of type 96 with borrowing once. |
| SV11 | I | Student solves printed subtraction exercise, borrowing 2 or 3 times. |
| SV12 | I | Student solves printed subtraction exercise, borrowing 2 or 3 times, one borrow from a 1 (not at left of minuend). |
| SV13 | I | Student solves printed subtraction exercise, using combinations of skills from types SV6 to SV12. |
| SV14 | I | Student solves printed subtraction exercise, borrowing from a 1 at left of minuend. |
| SV15 | I | Student solves printed subtraction exercise borrowing from a 0. |
| SV17 | I | Student solves printed subtraction exercise, $a10b - cdef$ ($0 \le b < f$; any or all of c, d, e might be zero). |
| SV19 | I | Student solves printed subtraction exercise $a00b - cdef$ ($1 \le a$, $0 < d$, $0 < e$, $0 \le b < f$). |
| SV20a | I | Student solves printed decimal subtraction exercise $a.b - c.d$ ($c < a$, $d < b$). |
| SV20b | G | Student writes in vertical form exercise of type SV20a given orally and solves it. |

| Class name | Type | Description |
|---|---|---|
| SV23 | I | Student solves printed decimal subtraction exercise with borrows (not from 0 or 1), same number of columns after decimal point in minuend and subtrahend. |
| SV24 | I | Student solves printed decimal subtraction exercise of type SV23 except that borrowing may be from 1 not at left of minuend. |
| SV27 | I | Student solves printed decimal subtraction exercise, varying number of columns after decimal point. |
| SV29 | I | Student solves printed subtraction exercise with decimal minuend and integer subtrahend. |
| SF2a | I | Student solves horizontally printed fraction subtraction exercise $a/b - c/b$ ($1 \leq b \leq 10$ or $b = 100$, $c < a$). |
| SF2b | G | Exercise of type SF2a given orally. Student writes both exercise and answer. |
| MO1 | G | Multiplication exercise $a \times b$ ($1 \leq a, b \leq 5$) given orally. Student writes answer. |
| MO3 | G | Multiplication exercise $a \times b$ ($1 \leq a, b \leq 9$) with $a > 5$ or $b > 5$ given orally. Student writes answer. |
| MO4 | G | Multiplication exercise $a \times 0$ ($0 \leq a \leq 9$) given orally. Student writes answer. |
| MO6 | G | Multiplication exercise $a \times 10$ or $10 \times a$ ($1 \leq a \leq 9$) given orally. Student writes answer. |
| MV2 | I | Student solves printed multiplication exercise $ab \times d$ or $abc \times d$ ($1 \leq b \times d$, $b \times c \leq 9$, $1 \leq a \times d \leq 19$). |
| MV4 | I | Student solves printed multiplication exercise $ab \times d$ or $abc \times d$ ($1 \leq a,b,c,d \leq 9$), carrying 1 once. |
| MV6 | I | Student solves printed multiplication exercise $abc \times d$ ($1 \leq a,b,c,d \leq 9$), carrying 1 twice. |
| MV8 | I | Student solves printed multiplication exercise $ab \times d$ or $bc \times d$ ($1 \leq a,b,c,d \leq 9$), carrying $n > 1$, once. |
| MV11 | I | Student solves (vertically) printed multiplication exercise $0 \times a$ or $a \times 0$ ($0 \leq a \leq 9$). |
| MV12 | I | Student solves printed multiplication exercise $ab \times d$ or $ace \times d$ ($1 \leq a \leq 9$, $b = 0$, $0 \leq c,e,d \leq 9$, at least one of $c,e,d$ is zero), no carrying. |
| MV14 | I | Student solves printed multiplication exercise $abc \times d$ ($b = 0$ or $c = 0$), carrying 1 once. |
| MV16 | I | Student solves printed multiplication exercise $abc \times d$ or $abce \times d$ (at least one of $b,c,e$ is zero), carrying once or twice. |
| DO1 | G | Division exercise $a \div b$ ($4 \leq a \leq 25$, $2 \leq b \leq 5$), quotient greater than 1, with or without remainder, given orally. Student writes answer. |

| Class name | Type | Description |
|---|---|---|
| DO2 | G | Divison exercise $a \div b$ $(1 \le a, b \le 9)$, quotient equals 1, with or without remainder, given orally. Student writes answer. |
| DO4 | G | Three numbers printed and a number n given orally. Student circles number divisible by n. |
| DO7 | G | Division exercise $a \div b$ $(0 \le a < b \le 9)$ given orally. Student writes answer. |
| DO8 | G | Verbal exercise using concept of dividing objects into n groups (without remainder), given orally. Student writes answer. |
| DV6a | I | Student solves printed division exercise $m \div n$ $(2 \le m \le 9,$ $m \le n < 10m)$ with remainder. |
| DV6b | G | Exercise of type DV6a given orally. Student writes both exercise and answer. |
| DV7a | I | Student solves printed division problem $m \div n$ $(2 \le m \le 9,$ $m \le n < 10m)$ without remainder. |
| DV7b | G | Exercise of type DV7a given orally. Student writes both exercise and answer. |
| DV8 | I | Student solves printed division exercise $m \div n$ $(2 \le m \le 9,$ $10m \le n < 1000m)$. |

*Note.* G = group exercise, I = individual exercise.

# Chapter 5

## AN ASSESSMENT OF TEACHER ATTITUDES

THOMAS TILSON AND BARBARA SEARLE

THIS CHAPTER reports on an investigation of the attitude of teachers toward radio instruction and related issues. The primary instrument for this purpose was a questionnaire. In addition, some teachers were interviewed; however, the results of the interviews support the findings from the administration of the questionnaire and only the latter are presented here.

The teacher plays an integral role in the implementation of the project lessons. Although during the broadcast she relinquishes her major teaching role, she must turn on the radio and carry out certain specified activities as described in earlier chapters. After the broadcast she is asked to continue the mathematics instruction, following the lesson plan provided by the project.

Because the role of the teacher is important to the success of a classroom program, it seemed essential that we examine the attitudes of the teachers with whom we worked. We were also interested in the attitudes of teachers who had heard about the experimental lessons but had had no direct experience with them. We therefore chose as the sample group all the first-grade teachers whose classes participated in the formal evaluation (described in chap. 3) either as experimental or control classes. The 30 radio classes and 24 traditional classes were selected at random in such a way that there were equal numbers from rural and [illegible] schools and equal numbers from each of the departments of Masaya, Granada, and Carazo.

The questionnaires were distributed at the end of the 1976 school year. They were hand-delivered to teachers at the time the posttests were administered, and the teachers were asked to return the completed forms to the office of the departmental inspector. About 50% did so; the remainder were contacted first by telegram and then in person at their homes. Another 40% of the questionnaires were obtained by this means. Ultimately, usable questionnaires were returned by all 30 teachers of experimental classes and by 21 of the 24 teachers of control classes.

In responding to the questions, the teachers of experimental classes were asked to reflect on their actual experiences with the radio lessons; teachers of control classes were given a description of the project lessons and were asked to respond according to their expectations. The amount of other information about the project lessons available to the control teachers varied. Before their classes were given the pretest, they had received a letter informing them of their selection as control teachers. When the tests were given, many of the teachers asked the test administrators for additional information about the project lessons. In Granada, a school official met with these teachers to explain the function of the control group in the project evaluation.

Every attempt was made to encourage teachers to respond freely to the questions; they were told that their replies would be treated as confidential and that the questionnaires were identified by code numbers known only to the project staff.

The questionnaire is divided into four parts. Part I consists of two open-ended sentences that call for completion, and the last section, Part IV, asks for background information. The remainder of the questionnaire contains 50 statements with a five-point agree-disagree scale displayed in the following form:

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

Part II uses this format to solicit attitudes on mathematics, the teaching of mathematics, and teaching as a profession. Part III is devoted entirely to radio instruction. The full text of the questionnaire (in Spanish), including instructions to teachers, is given in Appendix A of this chapter.

## 1. DEVELOPMENT OF THE QUESTIONNAIRE

Development of the teacher questionnaire began in 1974 shortly after the project began operations in Nicaragua. After discussion, four topics were selected for assessment: teachers' attitudes towards mathematics, the teaching of mathematics, the use of instructional radio, and teaching as a profession.

The first step was to interview several first-grade teachers about these topics. After the interviews, which were viewed by the staff as only moderately useful, an amplified list of topics was prepared. We decided to ask teachers about their own attitudes and also ask them to assess how their students felt about mathematics and the use of radio instruction.

Mathematics and the teaching of mathematics were viewed from two different perspectives. First, the subject of mathematics was treated alone and, second, the teachers were asked to compare mathematics with social studies, another important, required subject very different from mathematics.

Several response formats were considered before the decision was made to cast the bulk of the questionnaire as statements with an accompanying five-point agree-disagree (Likert) scale. The Likert scale was adopted because it is direct and easy for the teachers to use, but it is subject to bias on the part of the respondent because of individual tendencies to agree or disagree. Therefore we included in the questionnaire a section using a more open-ended type of response, pilot-testing items that used both semantic-differential and incomplete-sentence techniques. The results suggested that the incomplete sentences would provide better information.

For most of the statements and sentences the following tryout procedure was used. First, members of the office staff criticized each item. After revision, the draft items were administered to a group of primary-school teachers attending a night course taught by a staff member at a nearby university. After further revision, draft items were given to two groups of primary-school teachers in the city of Masaya, who were specifically asked to identify unclear items. At each stage in the tryout process, the staff member administering the draft items discussed them with the respondents. Some items were deleted because the responses correlated poorly with items thought to be similar.

In the final form of the questionnaire, most subcategories of the four major topics were represented by at least two statements, one phrased so that agreement indicated a favorable attitude toward project objectives, the other so that disagreement could be so interpreted. At first we planned to phrase half of the statements positively, half negatively (e.g., Children like mathematics; children do not like mathematics). We found, however, that the negative construction was poorly understood, and the final version contained only seven such items.

The questionnaire developed by this procedure was first used in November 1974. It was further revised and administered again in the fall of 1975 and 1976. The 1976 administration of the questionnaire is the subject of this chapter.

In the following pages we first describe the population of teachers and then present results, summarizing first the responses to the open-ended sentences and then the agree-disagree statements. Finally, we explore some of the relationships between teachers' characteristics and their responses.

## 2. DESCRIPTION OF THE TEACHER POPULATION

The 51 teachers who returned questionnaires had been selected at random from schools in the departments of Granada, Carazo, and Masaya; half were from rural schools and half from urban schools. Thus their responses can be considered typical of teachers in this area of Nicaragua, which is predominantly rural and small-town yet within 50 kilometers of Managua, the capital city. We summarize here the characteristics of the population, comparing teachers of experimental and control classes where that is appropriate. (Not all questionnaires were completely filled out, so in some cases there are fewer than 51 replies.)

The age distribution is shown in Table 1 in intervals of five years. The teachers ranged in age from under 20 to over 40, but two-thirds of them were 30 or younger. Their teaching experience is summarized in Table 2, which shows the distributions for total teaching experience, number of years teaching first grade, and number of years teaching in the same school. Although half of the teachers had had at least 6 years of experience, relatively few had taught this long at the first-grade level or in the same school.

There were 43 women and 8 men in the sample. Surprisingly, all the men taught in rural schools. Beyond this, there were no significant differences related to sex. Both men and women were equally experienced and equally likely to be school directors.

The teachers were asked several questions about their education. Five reported having less than a secondary school degree; one had

TABLE 1

Age of Teachers in Questionnaire Sample

| Age range in years | Number of teachers |
|---|---|
| 15–20 | 1 |
| 21–25 | 16 |
| 26–30 | 17 |
| 31–35 | 2 |
| 36–40 | 3 |
| over 40 | 7 |

TABLE 2

Experience of Teachers in Questionnaire Sample

| Years | Number of Teachers | | |
|---|---|---|---|
| | Total experience | Teaching first grade | In same school |
| Less than 2 | 3 | 10 | 9 |
| 2–5 | 19 | 29 | 32 |
| 6–10 | 11 | 3 | 2 |
| More than 10 | 15 | 6 | 5 |
| No response | 3 | 3 | 3 |

completed only primary school and the other four had a *Certificado de Aptitud*, a degree no longer granted that represents two years of postprimary work. Forty secondary-level degrees were reported, 4 from high school and 36 from normal school. No higher degrees were listed. Three of the degrees were obtained before 1950, three in the 1950s, 16 in the 1960s, and 26 in the 1970s. There were no interactions between educational background and either sex or urban-rural location of the school.

Several questions probed the role of the teacher in the school and the number of grades she was teaching. During the year, 15 of the teachers, almost one-third of the sample, also served as school directors. This position is not reserved for older teachers; 10 of the teachers in this group were 30 or younger. Thirty-seven of the classrooms represented by the sample had only first-grade students, four classrooms had both first and second graders, and nine classrooms had children at three or more grade levels.

Several differences between urban and rural schools emerged from the data. Only one urban teacher also served as a school director while 14 rural teachers did so. (Because rural schools are smaller, often one of the teachers also serves as director, while urban schools are large enough to support a director who does not also teach.) All the classes with more than one grade level in the classroom were in rural schools. However, the teachers themselves did not differ in experience, age, or educational background. Thus, there was no evidence in this small sample (as has been found elsewhere) that teachers in the rural areas were younger, less well prepared, or less experienced. In this respect, the rural area with which the project worked does not seem typical of those found in remote regions of other developing countries and perhaps of Nicaragua as well.

We can summarize these findings by drawing a composite picture of a first-grade teacher in the area from which our sample was drawn. The teacher is a woman in her twenties. She was graduated from normal school within the last 10 years and began teaching almost immediately. She has taught first grade at least once before and has been in her present school for several years. If she teaches in a rural area there is a good chance that before she is 30 she will combine classroom teaching with the job of school director. If she is teaching in an urban school she has only first graders in her classroom, but as a rural teacher she is likely to have students in other grades as well.

The data were examined for differences between teachers of experimental and control classes; no significant differences were found for any of the variables discussed above. Teachers were also asked to indicate their familiarity with and use of the project lessons and here differences between the two groups emerged, although not as many as had been anticipated. Table 3 reports the results of asking the teachers, "How many times have you talked with someone about the project?" For both groups, the majority report 3 to 10 conversations. When asked how familiar they were with the use of project lessons (Table 3), almost all experimental teachers but very few control teachers acknowledged a high level of familiarity. Nevertheless, only two teachers in the control group reported being completely unfamiliar with the project lessons. The responses presented in Table 3 are, of course, self-reports and must therefore be interpreted cautiously. However, the results seem plausible.

The teachers were asked if they used project lessons and, if so, to

TABLE 3

Teacher Familiarity with Project

| Number of conversations | Number of teachers | |
|---|---|---|
| | Experimental | Control |
| Less than 3 | 3 | 7 |
| 3–10 | 18 | 12 |
| More than 10 | 7 | 2 |
| No response | 2 | 0 |
| Familiarity with lessons | | |
| Much | 23 | 2 |
| Some | 6 | 9 |
| A little | 0 | 8 |
| None | 0 | 2 |
| No response | 1 | 0 |

mark the months of the year during which the program was used. Twenty-eight experimental teachers replied, 26 affirmatively. Three control teachers reported using the lessons; in the follow-up question, one of these teachers reported usage during one month, another during five months. The third teacher did not respond to this question. It is not clear to what extent these teachers made use of the radio lessons since, to our knowledge, they did not have the student worksheets that were an integral part of the course. Two experimental teachers reported not using the radio lessons at all, another reported usage during four months, and another for seven months. The remaining experimental teachers reported using the lessons for at least eight months during the school year. Thus, most experimental teachers report a pattern of consistent usage.

## 3. INCOMPLETE SENTENCES

Part I of the questionnaire contains two incomplete sentences about using radio for instruction:

1. When I think about the possibility of using radio instruction to help me teach I . . .
2. What I fear most in using radio lessons to teach mathematics is . . .

Using the actual responses as a guide, a list of categories was developed for coding each of the sentence completions. Each category was characterized, if possible, as favorable or unfavorable toward the use of radio for instruction. The distribution of responses is shown in Table 4. Many of the sentence completions contained multiple opinions; 76 responses were recorded for statement 1 and 64 responses for statement 2. Control teachers gave, on the average, about as many responses as experimental teachers, about 2.6 as compared with 2.8. For statement 1 the responses of the experimental teachers were markedly more favorable than those of the control teachers. Statement 2 solicited an unfavorable response, and most completions were of this character.

Table 5 lists all responses made by two or more teachers, in order of frequency. Because the list contains responses for both statements, there are many unfavorable comments. The most frequent comment is "Radio lessons help the children learn." Among the other favorable comments occurring frequently are "Radio lessons motivate children and make them more interested in class," and "Radio lessons help the teacher." Among the most frequent unfavorable comments are "Radio lessons are difficult and/or of limited benefit to the children," "The children will not be interested in or motivated by radio lessons,"

TABLE 4

Classification of Teacher Responses to Open-ended Statements

| Direction of response | Number of responses | | |
|---|---|---|---|
| | Experimental[a] | Control[b] | Total |
| | Statement 1 | | |
| Favorable | 34 | 12 | 46 |
| Unfavorable | 4 | 6 | 10 |
| Unclassifiable | 11 | 9 | 20 |
| TOTAL | 49 | 27 | 76 |
| | Statement 2 | | |
| Favorable | 8 | 2 | 10 |
| Unfavorable | 27 | 22 | 49 |
| Unclassifiable | 1 | 4 | 5 |
| TOTAL | 36 | 28 | 64 |

[a] ($N = 30$). Not responding: statement 1, 3; statement 2, 1.

[b] ($N = 21$). Not responding: statement 1, 1; statement 2, 1.

and "Children who are absent frequently won't be able to follow the lessons." The comments in Table 5 represent approximately 80% of the responses recorded. Several teachers of control classes indicated that they were unable to respond because they needed more information.

At the end of the questionnaire the teachers were asked to make additional comments. More than 70% of the experimental group and just under half of the control group did so. These remarks were coded using the categories developed for the open-ended statements. The distribution of unfavorable and favorable remarks is shown in Table 6. For the most part these remarks were parallel to those reported above. The major comment for both groups was that the radio lessons would motivate the children and make them interested in the classes. Some experimental teachers thought that the radio lessons were easier for the teacher, or the children, or both, and that the lessons helped the children learn mathematics. Some control teachers expressed interest in participating. The major unfavorable comments for the experimental teachers were that the mathematics content of the lessons was not adequate and that radio lessons cannot accommodate children of different abilities. Of major concern to some control teachers, and to a lesser extent to experimental teachers, was that the lessons would be difficult for the children and of limited benefit to them.

## 4. AGREE–DISAGREE STATEMENTS

### *Scoring Procedure*

The statements used to elicit agreement or disagreement (Parts II and III) were presented in both positive and negative constructions. In addition, the statements were framed to elicit both favorable and unfavorable attitudes about the topic under consideration. In order to

TABLE 5

Teachers' Responses to Open-ended Statements

| Synopsis of comment | Number of teachers | | |
|---|---|---|---|
| | Experimental | Control | Total |
| RL[a] help children learn | 7 | 6 | 13 |
| RL are difficult and/or of limited benefit | 5 | 6 | 11 |
| RL motivate children and make them more interested in class | 8 | 2 | 10 |
| RL help the teacher | 4 | 4 | 8 |
| Children who are absent frequently won't be able to follow the lessons | 4 | 3 | 7 |
| Children will not be interested in or motivated by RL | 2 | 5 | 7 |
| RL can't accommodate children of different abilitites | 5 | 2 | 7 |
| Children don't have the ability to listen | 2 | 4 | 6 |
| The mathematics content of the lessons is not adequate | 6 | 0 | 6 |
| The radio lessons are interrupted frequently | 4 | 1 | 5 |
| RL are easier for the teacher and/or children | 3 | 1 | 4 |
| The program should continue | 3 | 0 | 3 |
| Teachers won't receive materials | 1 | 2 | 3 |
| Lessons are boring, mechanized | 2 | 1 | 3 |
| RL are difficult when there is more than one grade in the classroom | 0 | 2 | 2 |
| RL are a help in general | 2 | 0 | 2 |
| Children will have problems when changing from one school to another | 2 | 0 | 2 |

[a] RL = radio lessons.

TABLE 6

Classification of Teacher Remarks on Questionnaire

| Direction of response | Number of teachers | | |
|---|---|---|---|
| | Experimental[a] | Control[b] | Total |
| Favorable | 24 | 4 | 28 |
| Neutral | 3 | 10 | 13 |
| Unfavorable | 18 | 3 | 21 |
| TOTAL | 45 | 17 | 62 |

[a] ($N = 30$). Not responding: 7

[b] ($N = 21$). Not responding: 10

compare the responses to different but related questions, the responses were coded in such a way that a favorable attitude toward the issue was given a high score. Thus, statements framed so that agreement indicated a favorable attitude were scored from 5 for ¡Sí! to 1 for ¡No!; statements framed so that agreement indicated an unfavorable attitude were scored from 1 to 5. For example, consider the first two questions (A–1 and A–2) in Table 7 presented below. Strong agreement with the first statement, "Radio instruction will bore children," was scored 1. Strong agreement with the second statement, "Children will find radio instruction exciting," was scored 5. The direction of scoring for each question is shown in the table in the column labeled "+."

In discussing the results we first examine the mean scores for individual items and comment on those for which the difference between experimental and control teachers is greater than .5. Then we examine the statements to which teacher response was either strongly favorable or strongly unfavorable. For this purpose we consider those scores that are within .5 of the overall mean (3.60) to be neutral, those above 4.1 to be favorable, and those below 3.1 to be unfavorable. (Although a score of 3 represents a neutral response as the questionnaire was structured, we choose to interpret the results somewhat conservatively, taking the mean as a "neutral" response.)

### *Attitudes Assessed*

The 50 statements in the questionnaire are presented in three tables: 25 statements directly related to radio instruction are presented in Table 7; 19 statements about teaching and about mathematics are presented in Table 8; and the remaining 6 statements, which ask the teachers to compare their experiences in the present year with those of the previous year, are presented in Table 9. The wording of the statements shown in the tables is a paraphrase of the Spanish. The statements are not presented in the order in which they appeared on the questionnaire.

**Attitudes toward radio instruction.** Table 7, which reports responses to the topic of radio instruction, shows five questions for which the difference in score between experimental and control teachers is more than .5. These questions are A–1, B–1, B–2, G–1, and O–1. In each case, the score for the experimental group is higher. Thus, experimental teachers expect radio instruction to be less boring to children (A–1) and expect the children to be less passive (B–1, B–2) than do control teachers. Furthermore, the experimental teachers more strongly see radio instruction as a means for improving their own teaching (G–1) and as a help in developing better ways to evaluate children's work (O–1).

The experimental teachers expressed agreement with the following favorable attitudes toward radio instruction (i.e., the mean score on the relevant statements was greater than 4.1):

1. Children like radio lessons.
2. Teachers like to use radio lessons.
3. Radio lessons can help teachers improve their teaching methods.
4. Radio lessons can help teachers improve their methods of evaluation.
5. Radio lessons will not diminish the role of the teacher.
6. Visual and manipulable materials can be incorporated into radio lessons.

The control teachers responded favorably only to the second item in this list.

The experimental teachers expressed agreement with the following unfavorable attitudes toward radio instruction:

1. Radio lessons cannot accommodate the different ability levels of children.
2. Radio lessons do not allow the children to ask questions.

The experimental teachers also felt that radio lessons would not reduce the teacher's work. The control teachers agreed with these three points and also felt that radio lessons would cause the children to be passive.

In summary, the experimental teachers have a more favorable view

TABLE 7

Teacher Responses to Topic of Radio Instruction

| Topic code | Question | +[a] | Mean score | |
|---|---|---|---|---|
| | | | Experimental | Control |
| A–1 | RL[b] will bore children | D | 4.4 | 3.6 |
| A–2 | Children will find RL exciting | A | 4.4 | 4.1 |
| B–1 | RL don't offer sufficient activity for children | D | 3.7 | 2.8 |
| B–2 | RL will make children more passive in class | D | 3.4 | 2.6 |
| C–1 | I would like to use RL in my classroom | A | 4.2 | 4.2 |
| C–2 | I hope never to use RL in my classroom | D | 4.1 | 3.8 |
| D–1 | It will be easy to use RL in my classroom | A | 4.1 | 3.7 |
| D–2 | Teachers will be able to rest a little while using RL | A | 2.3 | 2.7 |
| D–3 | RL will reduce the teacher's work | A | 2.6 | 2.6 |
| E–1 | I would teach better without RL | D | 3.9 | 3.5 |
| E–2 | Children would learn more without RL | D | 3.9 | 3.4 |
| E–3 | RL are not very effective | D | 3.6 | 3.4 |
| F–1 | RL would help parents become more interested in their children's education | A | 3.5 | 3.7 |
| G–1 | Using RL will help teachers improve their teaching | A | 4.5 | 3.9 |
| G–2 | RL will help the teacher better organize his lessons | A | 4.4 | 4.0 |
| G–3 | RL will help the teacher develop more mathematics topics during the year | A | 3.4 | 3.3 |
| H–1 | RL will not benefit children because they cannot listen well | D | 3.6 | 3.2 |
| I–1 | A fixed broadcast schedule will not give the teacher sufficient flexibility to best teach her class | D | 3.5 | 3.2 |
| J–1 | RL would diminish the importance of the teacher | D | 4.3 | 3.9 |
| K–1 | RL can make use of visual materials | A | 4.2 | 4.1 |
| K–2 | I think children can work with manipulable materials during RL | A | 4.4 | 4.1 |
| L–1 | RL will interfere with personal relationships between teacher and children | D | 4.1 | 3.9 |
| M–1 | The problem with RL is that they cannot adjust to the rates at which children learn | D | 2.2 | 2.0 |

(TABLE 7, cont.)

| Topic code | Question | +[a] | Mean score | |
|---|---|---|---|---|
| | | | Experimental | Control |
| N–1 | A serious obstacle with RL is that children cannot ask questions | D | 2.9 | 2.5 |
| O–1 | RL will help teachers develop better ways of evaluating the pupils | A | 4.5 | 3.8 |

[a] "D" signifies that disagreement was scored positively; "A" signifies that agreement was scored positively.

[b] RL = radio lessons.

of the benefits of using radio for instruction but are in close agreement with control teachers on some of the major drawbacks associated with radio instruction. The one difference between the groups—regarding passivity—surely reflects the experimental teachers' experiences with the radio mathematics lessons, which maintain a high level of student activity.

**Attitudes toward teaching and toward mathematics.** Table 8 reports the attitude scores for statements about mathematics as a subject, the teaching of mathematics, and teaching as a profession. There are five statements for which the scores for the two groups differ by more than .5: P–1, S–2, U–2, W–2, and Y–1. The experimental teachers are more in agreement that children like mathematics (P–1) and that mathematics is not the principal cause of failure in school (W–2). Such responses might reflect a more positive attitude of the students toward the radio mathematics lessons. On the other hand, the control teachers feel more confident about their knowledge of and ability to teach mathematics (S–2 and U–2) than do the experimental teachers. Perhaps the lower level of confidence of the experimental teachers results from their exposure to the instructional methods of the radio mathematics program, which are probably new to them. The final result about preparation time (Y–1) is expected because teachers of radio classes have relatively little to prepare for the typical radio lesson.

Both groups of teachers strongly agree that simple materials help children learn mathematics. The experimental group reported feeling good about teaching mathematics. On the negative side, both groups agree that children find mathematics a difficult subject and that it takes more time to prepare for a mathematics class than for a social studies class. Control-group teachers see mathematics as a principal cause of failure; they also would not recommend teaching as a profession to their best students.

### TABLE 8

### Teacher Responses to Topics of Mathematics and Teaching

| Topic code | Question | +[a] | Mean score | |
|---|---|---|---|---|
| | | | Experimental | Control |
| P-1 | Most children like mathematics | A | 3.7 | 3.1 |
| P-2 | Children like social studies more than mathematics | D | 3.0 | 2.8 |
| Q-1 | Most children find mathematics an easy subject | A | 2.8 | 2.4 |
| Q-2 | Most children find that mathematics is the most difficult subject | D | 3.0 | 2.8 |
| R-1 | In private life I enjoy solving problems that require the application of mathematics | A | 3.9 | 4.0 |
| S-1 | Mathematics is too difficult | D | 3.8 | 4.0 |
| S-2 | I understand mathematics more easily than other subjects | A | 3.4 | 4.0 |
| T-1 | I feel good when teaching mathematics | A | 4.5 | 4.1 |
| U-1 | I feel more sure of myself teaching social studies than mathematics | D | 4.0 | 3.8 |
| U-2 | I feel more sure of myself teaching mathematics than any other subject | A | 3.2 | 4.1 |
| V-1 | Simple materials help children learn mathematical concepts | A | 4.6 | 4.8 |
| W-1 | In school, mathematics is more important than any other subject | A | 3.2 | 3.4 |
| W-2 | Of all school subjects, mathematics is the principal cause of failure | D | 2.6 | 2.9 |
| X-1 | It is easy to teach mathematics | A | 3.7 | 3.8 |
| X-2 | It is more difficult to teach mathematics than any other subject | D | 3.5 | 3.6 |
| Y-1 | It takes more time to prepare for a social studies class than a mathematics class | A | 2.2 | 2.9 |
| Z-1 | Teaching is a profession that does not offer much satisfaction | D | 4.0 | 3.8 |
| Z-2 | I would encourage my best students to become teachers | A | 3.2 | 3.0 |
| Z-3 | I would remain in teaching even though offered other work with more remuneration | A | 3.6 | 3.2 |

[a] "D" signifies that disagreement was scored positively; "A" signifies that agreement was scored positively.

**Comparison between 1975 and 1976.** The teachers were asked to compare their experiences in 1976 with those of the previous year. For teachers of experimental classes this meant a comparison between using radio and not using radio. The results are presented in Table 9. There are strong differences between the two groups on the first three statements: The experimental teachers report that students liked mathematics more and found it easier (AA–1, AA–2) in 1976 than in 1975, and that they themselves enjoyed teaching mathematics more (AA–3). The responses of the control teachers were neutral for these items. For the remaining three items the responses of the experimental teachers were less positive and there were no strong differences between the two groups of teachers.

### *Results*

The mean scores for experimental and control teachers for each statement are also shown in Tables 7, 8, and 9. The overall mean score for the experimental group is 3.76 (*SD* = .67) and for the control group, 3.44 (*SD* = .60). The difference between the means is not statistically significant.

Table 10 presents the patterns of responses from teachers in the two groups to all of the agree-disagree statements. The teachers

TABLE 9

Teacher Comparison of Experiences in 1975 and 1976

| Topic code | Question | +[a] | Mean score | |
|---|---|---|---|---|
| | | | Experimental | Control |
| AA–1 | My students liked mathematics more this year than last year | A | 4.4 | 3.7 |
| AA–2 | My students found mathematics more difficult this year than last year | D | 4.4 | 3.7 |
| AA–3 | I have enjoyed teaching mathematics more this year than last year | A | 4.5 | 3.9 |
| AA–4 | My confidence in teaching math has been greater this year than last year | A | 4.0 | 4.0 |
| AA–5 | It has been more difficult to teach mathematics this year than last year | D | 4.3 | 4.0 |
| AA–6 | It took more time to prepare for a mathematics class this year than last year | D | 3.7 | 3.9 |

[a] "D" signifies that disagreement was scored positively; "A" signifies that agreement was scored positively.

TABLE 10

Distribution of Responses to Agree-disagree Statements

| Score | Experimental teachers | | Control teachers | |
|---|---|---|---|---|
| | Number of responses | Proportion | Number of responses | Proportion |
| 1 | 121 | .08 | 64 | .06 |
| 2 | 225 | .15 | 141 | .14 |
| 3 | 102 | .07 | 228 | .22 |
| 4 | 540 | .37 | 385 | .37 |
| 5 | 484 | .33 | 212 | .21 |

responded unfavorably to a relatively small proportion of the statements—23% and 20% for experimental and control teachers, respectively. The two groups differ substantially in the proportion of statements to which they indicated a neutral attitude; control teachers gave neutral responses three times as often as did experimental teachers. The larger proportion of neutral responses made by the control group is balanced by the relatively small proportion of strongly favorable responses.

The neutral responses of control teachers occurred more frequently to statements dealing with radio instruction (Part III), with which the teachers had no direct experience, as shown in Table 11, which presents score frequencies separately for the two sections of the questionnaire. It is also true, however, that the proportion of neutral responses is higher for the control teachers even on those statements related to their own experience.

Because of our concern about response bias produced by the Likert-type response format, we checked to see whether teachers responded differently to statements expressing favorable and unfavorable attitudes. We examined the data to determine whether teachers are more (or less) likely to respond favorably when a favorable response is indicated by agreement. Table 12 presents the numbers of favorable and unfavorable responses, categorized by the direction of coding, to 43 statements; the 7 negatively constructed statements were not used in this analysis. A significant chi-square test ($p > .02$) suggests that there is an interaction between favorableness of response and the direction of coding, although it is clear from Table 12 that the effect is small. In other words, teachers are slightly more likely to express a favorable attitude by agreeing than by disagreeing with the statement presented.

TABLE 11

Comparison of Responses to
Parts II and III of Questionnaire

| Score | Proportion of responses | | | |
|---|---|---|---|---|
| | Part II | | Part III | |
| | Experimental teachers | Control teachers | Experimental teachers | Control teachers |
| 1 | .08 | .07 | .08 | .06 |
| 2 | .18 | .13 | .13 | .14 |
| 3 | .06 | .17 | .08 | .28 |
| 4 | .36 | .39 | .37 | .36 |
| 5 | .32 | .24 | .34 | .17 |

## 5. RELATIONSHIP BETWEEN TEACHER CHARACTERISTICS AND RESPONSES

We examined the attitude toward radio instruction for groups of teachers classified along different dimensions. The mean score for the statements in Part III, calculated for each teacher, served as the measure. The mean of these mean scores for the experimental teachers was 3.8 ($SD = .52$) and for the control teachers, 3.4 ($SD = .40$). This difference is significant ($t = 2.64$, $p < .01$) but, as we noted earlier, the difference can be attributed to the higher proportion of neutral responses made by the control teachers.

TABLE 12

Test for Interaction Between
Direction of Coding and Direction of Response

| Direction of response | Number of responses | | | | |
|---|---|---|---|---|---|
| | Agreement coded + | | Disagreement coded + | | Total |
| | *N* | % | *N* | % | *N* |
| Favorable | 923 | .65 | 498 | .35 | 1,421 |
| Unfavorable | 274 | .59 | 190 | .41 | 464 |
| TOTAL | 1,197 | .63 | 688 | .36 | 1,885 |

As might be expected, the mean attitude score for teachers who said they understood the radio instructional program well (3.7) was higher than for those who said they understood it poorly (3.3). There was no difference in the attitude scores between young and old teachers or between poorly and well-trained teachers.

We examined the interaction of attitude scores and program usage for teachers of experimental classes, who were classified as frequent users if they reported using the program for at least 9 months, otherwise as infrequent users. The mean attitude score for statements on radio instruction was 3.9 for the frequent-use group and 3.6 for the infrequent-use group. Although this difference is not statistically significant, it is in the predicted direction. The two groups were not different on any other dimensions.

We were able to distinguish between the teachers by their propensity to respond strongly to the attitude statements in Parts II and III. The number of strong responses (1 or 5), moderate responses (2 or 4), and neutral responses (3) was tabulated for each teacher. A teacher was characterized as a strong responder if more than half of his responses were either 1 or 5, and as a moderate responder if more than half were either 2 or 4. Using this criterion, 19 teachers were identified as strong responders and 24 as moderate responders. The remaining 8 had fewer than half their responses in either category. Table 13 shows the distribution of the style variable in the experimental and control groups. The experimental group has relatively more strong responders. The table also shows the mean score for attitude towards radio instruction: The more strongly the teachers expressed themselves, the more favorable was their attitude towards radio instruction. There was no interaction between style and age; that is, younger and older teachers were equally likely to express themselves strongly. However, there was an interaction between style and level of

TABLE 13

Examination of Teacher Response Style

| Response style | Number of teachers |  | Mean Score[a] Attitude toward radio instruction |
|---|---|---|---|
|  | Experimental | Control |  |
| Strong | 14 | 5 | 4.0 |
| Moderate | 13 | 11 | 3.5 |
| Neither | 3 | 5 | 3.2 |

[a] $F = 11.99$; $df = 2, 51$; $p < .01$.

TABLE 14

Interaction between Response Style and Level of Understanding about Project

| Response style | Number of teachers<br>Level of understanding<br>High | Low |
|---|---|---|
| Strong | 18 | 1 |
| Moderate | 19 | 5 |
| Neither | 4 | 4 |

*Note.* Chi square = 7.19, $p < .05$

understanding of the program, as shown in Table 14. All but one of the teachers who expressed themselves strongly felt they understood the project well.

These findings are perhaps not surprising. One would expect those who are more familiar with the program to express themselves more strongly. However, the consistency of the results lends support to the conclusion that the teachers who were familiar with the program responded favorably to it.

## 6. CONCLUSION

The three major sources of information about the teachers' attitudes toward radio instruction in general and toward the radio mathematics lessons in particular were the incomplete sentences of Part I, the agree-disagree statements of Parts II and III, and the general comments at the end of the questionnaire. We summarize here the teachers' attitudes by listing those issues or statements for which at least two of these three sources provide support.

Teachers of experimental classes had favorable attitudes in the following areas:

1. The radio lessons help the children to learn.
2. The lessons help the teacher.
3. The lessons motivate the children and make the class more interesting.
4. The lessons make it easier for the children and/or teacher.

The experimental group responded unfavorably in the following two areas:

1. The mathematics content of the lessons was not sufficient; the teachers would normally cover more material during the year.
2. The radio lessons cannot adjust to the different abilities of the children.

Teachers of control classes were quite consistent in the attitudes expressed. Their favorable comments were:

1. They would like to participate in using the radio lessons.
2. The lessons would motivate the children and make the classes more interesting.

Their unfavorable comments were:

1. The lessons would be difficult for the children or would be of limited benefit.
2. The radio lessons cannot adjust to the different abilities of the children.

# APPENDIX A

## TEACHER QUESTIONNAIRE

The questionnaire text shown on the following pages is that prepared for teachers in the experimental group. Text changes to make questions appropriate for the control group, who did not use radio lessons, are shown in brackets [ ]. Such changes are to be found in the introduction to Part I, in the introduction to Part III, and in the body of Part III, where the wording for control teachers uses the subjunctive.

## INTRODUCCIÓN DEL CUESTIONARIO

Usted es uno (a) de los profesores de este Departamento que han sido seleccionados para participar en una parte del trabajo de investigación del Proyecto Matemática por Radio que este año funcióna en los Departamentos de Masaya, Granada y Carazo. Por esta razón, le estamos adjuntando un cuestionario. Sabemos que necesitará parte de su valioso tiempo para contestarlo, lo cual se lo agradecemos de antemano.

Su colaboración es sumamente importante para nosotros y posiblemente para Ud. ya que con ellos contribuiramos al desarrollo de la educación en Nicaragua.

La información que arroje el cuestionario nos proporcionará dos tipos de ayuda:

a. Para desarrollar un programa que esté de acuerdo a las necesidades y deseos del maestro.

b. Para evaluar la efectividad del Proyecto mismo.

Todas sus respuestas se considerán estrictamente confidenciales. Además no es necesario que escriba su nombre; cada cuestionario tiene registrado un número. El Proyecto no usará datos o nombres particulares de aquellas personas que participen en la investigación.

Esperamos que respondan con el mayor grado de sinceridad ya que de ello depende la utilidad que obtendremos de su respuesta.

El cuestionario consta de cuatro partes:

La primera le pide que complete dos oraciónes.

La segunda le pide que responda a unas oraciónes que se refieren a la Matemática, la enseñanza de la Matemática, y el Magisterio como profesión.

La tercera le pide que responda a unas oraciónes relacionadas con la instrucción por radio.

La cuarta parte se refiere a la información que tiene usted, sobre el Proyecto, a la situación actual de su trabajo y además, se incluyen algunos datos personales.

Cada una de las partes del cuestionario lleva una instrucción introductoria en la parte superior de la hoja. Ahora, sírvase voltear la hoja para ubicar la Primera Parte. Este cuestionario le tomará aproximadamente cuarenta minutos para llenarlo.

## PARTE I

A continuación aparecen dos oraciónes incompletas. Sírvase completarlas en un párrafo expresando su propio criterio. En la completación de las oraciónes, puede extendarse lo que usted estime conveniente.

1. Cuando me pongo a pensar sobre la posibilidad de seguir utilizando la instrucción por radio, para ayudarme en la tarea de enseñar, entonces yo . . . [Cuando me pongo a pensar sobre la posibilidad de usar la instrucción por radio, para ayudarme en la tarea de enseñar, entonces yo . . .]

2. Lo que más temo con el uso de las lecciónes por radio, para enseñar Matemática es . . . [Lo que más temo al usar las lecciónes por radio, para enseñar Matemática es . . .]

## PARTE II

La segunda y tercera parte tienen el mismo formato.

En la segunda parte deseamos obtener información acerca de lo que usted piensa de la Matemática, la enseñanza de la Matemática, y del Magisterio como profesión. Al respecto, le presentamos 25 oraciónes sobre las cuales usted debe responder.

Debajo de cada oración aparecen 5 posibles respuestas en línea horizontal. Usted debe marcar, solamente, sobre una de las cinco respuestas. La respuesta que marque debe ser aquella que exprese su propio criterio.

**Ahora, busque abajo el ejemplo.**

**"Todos los niños deben ir a la escuela, aunque siquiera por corto tiempo."**

| _____ | _____ | _____ | _____ | _____ |
|---|---|---|---|---|
| ¡Sí! | Sí | ? | No | ¡No! |

**Usted debe responder colocando una marca en uno de los cinco lugares debajo de la oración usando la siguiente guía. Si usted está absolutamente de acuerdo con la oración, ponga una marca sobre el "¡Sí!". Si está de acuerdo, pero no absolutamente, ponga la marca en el espacio "Sí". Si no está seguro, ponga la marca sobre "?". Si está en desacuerdo con la oración póngala sobre "No". Si está absolutamente en desacuerdo con la oración póngala sobre "¡No!". Lo que sigue es un resumen de lo anteriormente explicado, lo cual le servirá de clave, para llenar la segunda y tercera parte del presente cuestionario.**

¡Sí! = absolutamente de acuerdo con la oración
Sí = de acuerdo con la oración
? = no se; tengo dudas
No = en desacuerdo con la oración
¡No! = absolutamente en desacuerdo con la oración

Ponga atención en que algunas de las oraciónes tienen una forma negativa. Véamos los siguiente ejemplos:

Ejemplo a:
Los pájaros no tienen alas.

| _____ | _____ | _____ | _____ | _____ |
|---|---|---|---|---|
| ¡Sí! | Sí | ? | No | ¡No! |

La respuesta es evidente ¡No!, ya que los pájaros verdaderamente tienen alas. Si Ud. hubiera marcado en ¡Sí! estariá afirmando que los pájaros no tienen alas, lo cual contradice la verdad de que ellos poseén alas.

Ejemplo b:
Los niños no deberian asistir a la escuela.

| _____ | _____ | _____ | _____ | _____ |
|---|---|---|---|---|
| ¡Sí! | Sí | ? | No | ¡No! |

Recuerde que tiene que responder de acuerdo a la oración. Por ejemplo, si considera que los niños deberian ir a la escuela tiene que marcar "¡No!" o "No" lo cual indica que está en desacuerdo con la oración. Es decir considera que los niños deberian de asistir a la escuela.

Si considera que los niños no deberian asistir a la escuela, debe de marcar en "¡Sí!" o "Sí", lo cual indicaría que está de acuerdo con la oración, es decir considera que los niños no deberian asistir a la escuela.

Si entiende bien la oración, no se detenga mucho tiempo en cada cuestión para responder, no piense en detalles. La mejor respuesta será aquella que acuda primero a su mente.

1. A la mayoría de los niños les gusta la Matemática.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

2. Me siento más seguro de mi mismo, cuando enseño Estudios Sociales, que cuando enseño Matemática.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

3. En la vida particular, fuera de la escuela, me siento feliz resolviéndo aquellos problemas en los cuales se aplica la matemática.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

4. Los materiales sencillos le sirven mucho a los niños, para captar los conceptos matemáticos.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

5. Me siento conforme cuando enseño Matemática.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

6. Toma más tiempo para preparar una clase de Estudios Sociales, que una clase de Matemática.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

7. En la escuela, la Matemática es más importante que cualquier otra materia.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

8. La Matemática es demasiado difícil.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

9. De todas las materias, la Matemática es la causante principal del fracaso de los niños en la escuela.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

10. A los niños les gusta más los Estudios Sociales, que la Matemática.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

11. Me siento mas seguro de mi mismo enseñando la Matemática, que cualquier otra materia.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

12. Es fácil enseñar la Matemática.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

13. El Magisterio es una profesión que ofrece mucha satisfacción.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

14. La mayoría de los niños consideran que la Matemática es una asignatura fácil.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

15. Yo alentaría a mis mejores alumnos a seguir la carrera de Magisterio.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

16. Comprendo la Matemática más fácilmente que otras materias.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

17. Yo permanecería en el Magisterio, aunque me ofrecieran un trabajo más remunerado.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

18. Los niños consideran que la Matemática es la asignatura más difícil.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

19. Es más difícil enseñar matemática que cualquier otra asignatura.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

20. La enseñanza de la Matemática este año, me ha agradado más que la del año pasado.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

21. A mis alumnos de este año les ha gustado más la Matemática que a los del año pasado.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

22. Enseñar la Matemática este año, ha sido más difícil que el año pasado.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

23. Mi confianza en la enseñanza de la Matemática este año, ha sido mayor que el año pasado.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

24. Se tomó más tiempo preparar una clase de Matemática este año, que el año pasado.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

25. Mis alumnos de este año han encontrado la Matemática más difícil que la del año pasado.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

## Parte III

En esta sección, nos gustaría saber que ideas tiene usted acerca del uso de la instrucción por radio. Las lecciónes de Matemática que este año se aplican en su grado, el año que viene se transmitirán a un mayor número de escuelas del país. Tenemos mucho interés en adelantar algunas ideas sobre el posible impacto de la instrucción por radio, en los maestros y en los niños. Por lo tanto, nos gustaría que usted respondiera a las siguientes oraciónes basado en sus experiencias personales con este Proyecto. Algunas oraciónes le pedirán que opine sobre su propia clase.

[En esta sección nos gustaría saber que ideas tiene usted acerca del uso de la instrucción por radio. Esta parte tiene 25 oraciónes sobre las cuales debe responder en forma igual a la parte anterior. Es posible que usted nunca haya enseñado con la ayuda del radio. Por lo tanto, quizás tenga dificultades para responder a esta parte del cuestionario. Sin embargo, aunque nunca lo haya usado nos interesa saber que impresión tiene usted acerca de la instrucción por radio.]

[La instrucción por radio puede tener características muy diversificadas. Pero el tipo de instrucción que nosotros estamos diseñando es muy especial y difiere a la comunmente conocida. Esta consiste, en transmisiónes todos los días dirigidas directamente al aula durante la hora correspondiente a la clase de Matemática. El tiempo empleádo durante la transmisión es aproximadamente la mitad del que usted comunmente empléa en la clase de Matemática y los contenidos de las lecciones estarán sujetos estrictamente a los Programas Oficiales del país.]

[El maestro del aula participará directamente durante la transmisión de las lecciónes por radio y también, realizará una serie de actividades durante la otra mitad de la hora escolar dedicada a la clase de Matemática. Para una eficiente coordinación de las activitades, el programa por radio proveerá a los maestros de una Guía. Para responder al cuestionario de esta Parte III, conviene que antes resolverlo, piense un poco sobre el de la instrucción por radio explicada arriba.]

[Ahora, conteste las siguientes oraciónes tomando en cuenta siempre, el uso de la instrucción por radio anteriormente explicado.]

[Ahora, sírvase voltear la hoja para ubicar la Tercera Parte de este cuestionario.]

1. La instrucción por radio causa [causará] aburrimiento a los niños.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

2. Yo daría mejor mi clase sin usar la radio.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

3. Me gustaría seguir utilizando [usar] la instrucción por radio en mi aula.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

4. Los niños no saben escuchar bien. Por eso la instrucción por radio no los beneficia [beneficiará].

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

5. El problema de la instrucción por radio es que no les ofrece [ofrecería] suficiente oportunidad de participación a los niños.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

6. Ojalá que no tengo nunca la oportunidad de seguir usando [usar] la instrucción por radio en mi aula.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

7. Me es [será] fácil utilizar la instrucción por radio en la aula.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

8. Una transmisión radial, a la misma hora todos los días, no le da [dará] suficiente flexibilidad al maestro para enseñar mejor su clase.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

9. Los niños encontraron [encontrarán] emocionante la instrucción por radio.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

10. Los niños aprenden [aprenderían] más si los maestros no usan la instrucción por radio.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

11. Los maestros pueden [podrán] descansar un poco durante las transmisiónes.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

12. La instrucción por radio disminuye [disminuiría] la importancia del maestro.

| | | | | |
|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ |
| ¡Sí! | Sí | ? | No | ¡No! |

13. Escuchando las lecciónes por radio los maestros pueden [podrán] mejorar su sistema de enseñanza.

| | | | | |
|---|---|---|---|---|
| ¡Sí! | Sí | ? | No | ¡No! |

14. La instrucción por radio puede [podrá] hacer uso de materiales visuales.

| | | | | |
|---|---|---|---|---|
| ¡Sí! | Sí | ? | No | ¡No! |

15. La instrucción por radio interrumpe [interrumpirá] la interacción personal que debe de existir entre el maestro y los niños.

| | | | | |
|---|---|---|---|---|
| ¡Sí! | Sí | ? | No | ¡No! |

16. La instrucción por radio ayuda [ayudará] al maestro de aula a organizar mejor sus lecciónes.

| | | | | |
|---|---|---|---|---|
| ¡Sí! | Sí | ? | No | ¡No! |

17. Las lecciónes por radio reducen [reducirán] el trabajo del maestro.

| | | | | |
|---|---|---|---|---|
| ¡Sí! | Sí | ? | No | ¡No! |

18. Mediante a la instrucción por radio, creo que los niños pueden [podrán] trabajar con materiales manipulables durante la transmisión.

| | | | | |
|---|---|---|---|---|
| ¡Sí! | Sí | ? | No | ¡No! |

19. La instrucción por radio verdaderamente, no tiene [tendría] mucha efectivid

| | | | | |
|---|---|---|---|---|
| ¡Sí! | Sí | ? | No | ¡No! |

20. El problema con la instrucción por radio es que no se puede ajustar al ritmo diferente con que avanzan los grupos de niños.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

21. Un obstáculo serio en el aprendizaje por radio es que los estudiantes no pueden [podrían] hacer preguntas.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

22. La instrucción por radio ayuda [ayudará] a los maestros de aula a desarrollar mejores formas de evaluar a sus alumnos.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

23. La instrucción por radio le facilita [facilitará] al maestro desarrollar más temas de Matemática durante el año.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

24. La instrucción por radio hace [haría] a los estudiantes más pasivos en la clase.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

25. La instrucción por radio ayuda [ayudaría] a los padres a interesarse más por la educación de sus hijos.

| | | | | |
|---|---|---|---|---|
| ____ | ____ | ____ | ____ | ____ |
| ¡Sí! | Sí | ? | No | ¡No! |

## PARTE IV

1. Por favor, indique abajo el número de veces, aproximadamente, que usted ha conversado con otras personas (amigos, otros maestros, personas del proyecto, etc.,) acerca del Proyecto Matemática por Radio.

De 0 a 2 veces ____
De 3 a 10 veces ____
Más de 10 veces ____

2. ¿Entiende usted cómo se desarrollan las lecciones del Proyecto Matemática por Radio en las aulas?

Entiendo muy bien ____
Entiendo más o menos ____
Entiendo un poco ____
No entiendo nada ____

3. ¿Usó las lecciones de Matemáticas por radio durante algún periodo del año?

Sí ____ No ____

4. Si su respuesta anterior es "Sí" encierre en un círculo los meses en los cuales usó las lecciónes por radio.

| | | | | |
|---|---|---|---|---|
| Febrero | Marzo | Abril | Mayo | Junio |
| Julio | Agosto | Septiembre | Octubre | Noviembre |

5. Indique su domicilio ____________ ____________
6. Encierre el nombre del cargo que desempeña.

Director
Director con grado a mi cargo
Asistente
Asistente con grado a mi cargo
Profesor de grado

7. Encierre el grado(s) que tiene a su cargo.

| | | |
|---|---|---|
| primero | segundo | tercero |
| cuarto | quinto | sexto |

8. Encierre la palabra "Sí", si trabaja con grupos en la clase de Matemática o la palabra "No", si no trabaja con grupos en la clase de Matemática.

Sí No

9. Si su respuesta fue afirmativa, indique el número de grupos con los que trabaja en su clase de Matemática.

1 2 3 4 5

10. Encierre el intervalo en que está comprendida su edad.

de 15 a 20 años
de 21 a 25 años
de 26 a 30 años
de 31 a 35 años
de 36 a 40 años
41 años o más

11. Encierre el intervalo que indique el numero de años de ejerce en el Magisterio, incluyendo el actual.

menos de 2 años
de 2 a 5 años
de 6 a 10 años
11 años o más

12. Encierre el intervalo que indique el número de años que tiene de impartir clases en el grado que tiene actualmente bajo su cargo, incluyendo el actual.

menos de 2 años
de 2 a 5 años
de 6 a 10 años
11 años o más

13. Encierre el intervalo que indique el número de años que tiene de trabajar en la escuela donde actualmente da clases, incluyendo el actual.

menos de 2 años
de 2 a 5 años
de 6 a 10 años
11 años o más

14. Indique el nombre del Título o los títulos obtenidos.

Nombre del Título(s) ____________________

15. De el nombre de la institución en la cual aprobó el último año de estudio.

Nombre de la Institución ____________________

16. Indique la fecha en que aprobó el último año de estudio.

Fecha ____________________

17. Si está estudiando actualmente, sírvase dar el nombre de la institucion y el tipo de estudio que realiza.

Nombre de la Institución ____________________
Tipo de Estudio ____________________

18. Nos ha contestado muchas preguntas específicas. Reconocemos, sin embargo, que es posible que usted tenga algunas inquietudes sobre la Matemática y la instrucción por radio, las cuales no ha podido expresar libremente en este cuestionario. Por lo tanto, le invitamos a que manifeste sus inquietudes o comente algun tema o tópico que considere no está contemplado en el cuestionario. (Puede usar este espacio o usar el dorso de la hoja, también.)

____________________________________________
____________________________________________
____________________________________________
____________________________________________

## Chapter 6

# AN OBSERVATION STUDY IN FIRST-GRADE CLASSROOMS

THOMAS TILSON

RADIO, as an inexpensive and widely available medium, offers great hope for raising the quality of instruction in many developing countries, yet there is little information about the kinds of activities that can be expected of listeners. The study reported here, undertaken as part of the evaluation of the first-grade curriculum, focuses on observable classroom events—the verbal communications of the teachers, children, and radio characters, and the nonverbal activities of the teachers and children.

The project assumed responsibility for all of the mathematics instruction that children received. A daily lesson for the first grade consisted of a 20-minute radio broadcast (presented by tape recorder in 1975 when the data for this study were collected) followed by approximately 20 minutes of teacher-directed activities. No textbooks were used and printed material was limited to a one-page worksheet for each child each day. Spanish was the sole language of instruction.

An individual radio broadcast consisted of many segments, each one concentrating on a particular mathematical theme and lasting from one to three minutes. Interspersed among these segments were entertainment presentations such as stories, songs, jokes, and games.

During each radio lesson the children responded orally, physically, and in writing. Oral responses included singing and giving answers to arithmetic exercises and other questions asked by radio characters.

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The author wishes to thank the many Nicaraguan staff members whose help made this study possible. David Cardoza S., Emigdio Quintero C., Luis Ramírez A., Francisco Herrera P., and Piedad de Alvarado were classroom observers during the recording sessions. María Auxiliadora Cerrato de Cajina, Ines del R. Larios, and Patricia López S. carried out the detailed and time-consuming coding task. Guillermo Bojorge S. did an extremely accurate job of keypunching the data.

Physical responses included moves in simple games, work with concrete materials, and finger counting in arithmetic exercises. For the written responses, children were asked to draw, copy exercises, and write answers on worksheets.

Following the broadcast the teachers directed activities according to a teacher's guide produced and distributed by the project. These activities consisted mostly of exercises relating to the content of the broadcast but occasionally involved new subject matter, mathematical games, or other activities.

## 1. DESCRIPTION OF THE STUDY

The study was undertaken with two broad considerations in mind: first, the application of a relatively inexpensive technology to the problems of education and, second, a description of classroom activities in a developing country.

The study sought to add to our understanding of the use of instructional radio by documenting the activities and behaviors of teachers and children in the classroom. Many people not familiar with the project have expressed concern about using radio for teaching mathematics; they have assumed that radio could not actively involve the children, that visual and other materials could not be used, and that first-grade children could not adequately follow instructions presented by radio. As will become clear in later sections, these potential problems need not be a concern.

The second broad issue relates to the findings of the International Association for the Evaluation of Educational Achievement (1973–1976), which carried out a number of cross-national comparative studies beginning in 1965. Inkeles (1977) summarizes the findings related to the less developed countries. "What was distinctive about the less developed countries was the extremely poor showing they made on the tests, at all ages and largely without regard to the subject tested or the mode of testing" (p. 157). Inkeles presents several hypotheses about why the differences exist. Although it was not an objective of this study to make any cross-national comparisons, it was hoped that the descriptive data on classroom activities might shed light on the relationship between teaching practices and the relatively poor achievement levels in less developed countries.

This study examined activities of the teacher and children in both radio classes and traditional classes. The radio classes were divided approximately evenly in time between the broadcast and nonbroadcast portions. Some of the nonbroadcast activities took place just prior to the radio broadcast, but most occurred afterward. In both radio and traditional classes, the regular classroom teacher was present.

Two questions provided a focus for the study. In what ways is the experience of the children during the broadcast similar to, or different from, their experience during the nonbroadcast period and in the traditional classes? Does the radio exhibit unique characteristics when used for teaching in this setting, or is it similar to, or just a substitute for, the classroom teacher?

More specifically, I undertook to do the following:

1. To measure the extent to which the project incorporated specified activities or principles of instruction in the radio broadcasts.
2. To contrast the radio lessons with traditional classes.
3. To examine the role of the teacher during the radio broadcasts.
4. To look for important, but unexpected, behaviors or activities in the radio and traditional classes.
5. To look for consistent relationships between teacher or student behaviors and student achievement.
6. To describe the evolution of the radio broadcasts during the school year.

The first two points need further elaboration. The first objective of the study was to measure the occurrence of the following activities specified by the curriculum developers as being desirable to incorporate into the lessons.

*Active responding:* Instruction has been shown to be more effective when children respond actively. This principle has received substantial support in the research literature (see Suppes & Ginsberg, 1962) and is widely implemented in modern instructional programs (see Chu & Schramm, 1967). The project distinguishes three types of responses. The children may speak aloud, they may write, or they may respond physically, as by manipulating materials, drawing on their worksheets, counting with their fingers, or moving parts of their bodies in a game. This study analyzed each type of response separately and used all three together to determine the amount of student participation.

*Giving answers:* Providing children with knowledge of results facilitates learning in many settings (Stolurow, 1961). Similar results have been obtained for adults in highly controlled experimental situations by Bower (1962) and others. The project experimented with many different ways of giving answers and, to date, has found that the most successful method is to ask children to respond orally, and then have the radio give the correct answer. The study measures the extent to which both the radio and the classroom teacher gave answers.

*Concrete and visual materials:* There is almost universal agreement today that lower primary-level children should use concrete materials in order to facilitate the understanding of abstract concepts. The project incorporated manipulable materials such as bottle caps and seeds into the radio broadcasts. Visual materials, consisting of drawings on worksheets, were also used.

*Time spent on mathematics:* Within reasonable time limits and all other factors being equal, one would expect an increase in learning as the time devoted to mathematics increased. Thus, the project sought to maximize the percentage of lesson time spent on mathematics while still including entertainment presentations.

*Variety in the lessons:* Increased attention and motivation by students generally result in greater achievement. Therefore, the broadcasts included entertainment to provide an occasional break for the children and to increase their appreciation of the radio broadcasts.

*Pacing:* Research has shown that the more rapid the pace of a presentation, the more likely the children are to pay attention (Palmer, 1972). For this study the pace is determined by factors such as who is speaking, who is the person spoken to, and the content of the speech. Lessons were written to ensure a rapid pace.

*Praise:* Social approval has been found to be positively related to achievement. The results of using verbal praise, just one form of social approval, are less certain. Of 13 interpretable studies reviewed by Gage and Berlinger (1975) that relate the occurrence of praise to academic achievement, 8 showed positive correlations and 5 negative. It appears that the context in which praise is given and the characteristics of the person receiving the praise are important factors in its effectiveness. Despite the inconclusive results of such studies, the project made an effort to incorporate praise into the lessons.

The second objective of the study was to compare the activities during the radio lessons with those occurring in traditional classes. Of particular interest were the ways in which the radio activities were similar to or different from those of the regular teacher. Is the radio presentation just a substitute for the teacher, or does it exhibit unique characteristics? The curriculum developers expected the radio broadcasts to differ from traditional classes along the dimensions reflected in the preceding list of teaching principles—greater participation by the children, providing answers more often, greater use of concrete and visual materials, more time spent on mathematics and entertainment, a more rapid pace to the lessons, and greater use of praise. Nevertheless, several important characteristics of the class were expected to remain unchanged—domination of verbal time by the teacher (in this case the radio characters) and short responses and few questions by the children.

During the nonbroadcast period the project staff expected only subtle changes in the classroom activities. As in other situations when instructional technology has been introduced, the teacher might be expected to spend more time on administrative matters and correspondingly less time teaching mathematics. The project deliberately chose to limit the change in the teacher's role, particularly during the nonbroadcast period, because of the project's limited resources and research findings indicating that the less change an innovation requires, the more likely it is to be adopted (Rogers & Shoemaker, 1971).

## 2. METHODOLOGY

The sample for the study consisted of six volunteer teachers, selected to form a group representative of all teachers in the region. Five teachers were female; one was male. Four of the teachers taught in schools located in small cities or towns; two were in rural schools. The six participating teachers were, in fact, representative of a larger randomly selected group in many ways—ratio of male to female, teaching experience, attitudes towards radio instruction, and the pretest scores of their students. Nevertheless, they had more education and were older than those in the randomly selected group, their attitudes towards mathematics and teaching were less positive, and the posttest scores of their students were higher.

A repeated measures design was used for the study. The first data were collected at the end of the 1974 school year. (The school year runs from February to November.) These data, collected before the teachers had had any experience with instructional radio, provided a baseline or reference point. Radio lessons were introduced in 1975; data were collected at the beginning and the end of the year. In each time period, two or three mathematics classes of each teacher were recorded on tape.

Classes recorded in 1974 are referred to as *preradio* classes. The radio classes recorded at the end of the 1975 school year were used in this study as the typical radio lessons, and are referred to as just the *radio classes* or *radio lessons*. If radio classes at the beginning of 1975 are referred to, they are called the *early radio classes* or *lessons*. The radio classes or lessons consisted of two parts, the *broadcast* period and the *nonbroadcast* period, the latter consisting of the time devoted to the lesson before and after the broadcast.

The coding instrument, which was specially designed for this study, allowed for the coding of all public verbal interchanges and certain specified nonverbal actions. The duration of each event and the sequence of events were coded.

The coding instrument had three sections, each one designed to collect information at a different level. Part A collected data on the overall structure of the classroom and lesson: whether the radio was being used or not, whether the children were working in groups or all together, the lesson format (discussion, seat work, entertainment, administration, or nothing happening), and the use of concrete or visual materials.

Part B of the coding instrument was designed to provide specific and detailed information on different types of verbal communications and nonverbal actions: who was communicating to whom, length of utterance, whether it was a task direction or not, verbal content (mathematics, other lesson-related instructions, answer given by teacher or radio to a mathematics problem, praise, criticism, discipline, or something else), and nonverbal actions (writing on the chalkboard or worksheet, physical response with the body, manipulating concrete materials, correcting student's work, discipline, or something else).

Part C of the coding instrument was designed to include important but rarely occurring events: instances of higher thought processes or affect, teaching of terminology, and mathematical errors.

The coding was carried out directly from the audio cassettes by specially trained project staff members. The tapes consisted of a stereo recording, one channel for the public verbal interchanges as picked up by a microphone placed in the middle of the classroom and the other channel for comments made by a project staff member in the classroom who recorded important nonverbal activities or information.

Analyses were carried out on the data from the preradio classes and separately for the broadcast and nonbroadcast parts of both the early and late radio lessons. In each of the periods, the data for each characteristic were summed over the classes for each individual teacher, and then the data were summed over all teachers. For each characteristic, calculations were made based on total time, percentage of lesson time, and frequency. For certain analyses, different categories were combined before the summaries were calculated.

## 3. RESULTS

The results are presented in four sections. The first section describes the classroom activities during the radio lessons, treating the broadcast and nonbroadcast parts separately and, when appropriate, combining the data to give a picture of the whole class. In addition to examining the various characteristics of the lessons, the teacher's role is also described.

The second section provides a useful perspective on the radio lessons by comparing them with the traditional mathematics classes as exemplified by the preradio lessons. Whereas the first section compares the two parts of the radio lessons, this section compares both parts of the radio lessons with the preradio classes. In particular, the similarities and differences between the preradio classes and the nonbroadcast part of the radio lessons are discussed.

The third section examines the relationships between classroom characteristics and student achievement. Finally, the last section compares the classroom activities of the early radio broadcasts with those of the late radio broadcasts.

### *Radio Lessons*

The children's mathematics experience during the radio lessons was the sum of two distinct parts—the broadcast and the nonbroadcast portions. For some characteristics of the lessons it is worthwhile to combine the experiences for both parts of the lesson—for example, the amount of time spent on mathematics. For other characteristics, it seems best to present the data separately for each part of the radio lesson—for example, the amount of time spent on entertainment. In this case, an average score for both parts of the radio lesson is not useful because entertainment occurred almost totally during the broadcast. By analyzing the parts separately, we can focus on how the children's experience differed in the two periods and on the ways in which instruction by radio was or was not unique as compared with instruction by the classroom teacher.

On the average, the broadcasts lasted 22.2 minutes, and the nonbroadcast part 28.6 minutes, giving an average time for the radio lessons of 50.8 minutes. Thus, the broadcast part used 43.7% of the lesson time, and the nonbroadcast part 56.3%. Data presented for the total radio lesson are weighted averages based on the different time used for each part of the lesson.

In the discussions that follow, the term *radio* will be used to refer to the participation of the radio characters during the broadcasts.

**Lesson format.** Lesson format refers to the overall type of activity going on at any particular time in the classroom—discussion, seat work, type of entertainment, administration, or nothing happening. The percentage of lesson time spent in each of the categories is presented in Table 1. During the broadcasts three-quarters of the time was spent in the discussion format, indicating a continuing verbal interchange between the radio and the children. The remaining 25% of the time was devoted to entertainment. During the nonbroadcast periods, the situation was different, with a substantial percentage of

TABLE 1

Percentage of Lesson Time According to Lesson Format in Radio Classes

| Lesson format | Broadcast | Nonbroadcast | Total |
|---|---|---|---|
| Discussion | 74.0 | 55.6 | 63.6 |
| Seat work | 0 | 28.5 | 16.0 |
| Entertainment | 25.3 | 1.7 | 11.2 |
| Administration | 0 | 4.3 | 2.4 |
| Nothing | .4 | 7.7 | 4.5 |
| Not certain | .7 | 2.2 | 1.5 |

time given to discussion, 55.6%, and virtually no entertainment. Seat work took up 28.5% of the nonbroadcast period; administrative matters, 4.3%; and nothing happening, 7.7%.

There was, however, considerable variance among the teachers during the nonbroadcast period. For example, discussion ranged from 30.3% to 84.4%, seat work from 4.1% to 48.3%, administration from 0% to 8.4%, entertainment from 0% to 9.8%, and nothing happening from 0.5% to 8.9%.

**Time on mathematics.** The most important activity during mathematics class is doing mathematics or receiving instructions about an assignment in mathematics. The mathematics activity may be verbal or nonverbal and may be performed by the children, the teacher, or the radio characters. Even some entertainment activities have a mathematical content which would be included here. Other activities include administration, instructions not related to mathematics, entertainment not having mathematical content, discipline, normal pauses, and wasted time. During the broadcast, 75.8% of the time was spent on mathematics; the corresponding figure for the nonbroadcast period is 50.5%, with a range from 42.4% to 69.3%.

It is interesting to examine how much time each of the participants spent on mathematics. Table 2 shows the relevant data for radio, teacher, and children. During the broadcast, the radio spoke for 39.3% of the time about mathematics and the children spent 32.2% of the time on mathematics, including verbal and nonverbal actions. Virtually all of the remaining time was spent on entertainment without mathematical content. The teacher was involved a small percentage of the time, spending on the average 4.3% of the broadcast time on mathematics. During the nonbroadcast period the teachers spent 30.2% of the time on mathematics, ranging from 24.0% to 47.3%; and the children, 20.7%, with a range from 14.9% to 24.0%. Most of the

TABLE 2

Percentage of Lesson Time Spent on Mathematics in Radio Lessons

| Participant | Broadcast | Nonbroadcast |
|---|---|---|
| Radio | 39.3 | 0 |
| Teacher | 4.3 | 30.2 |
| Children | 32.2 | 20.3 |
| TOTAL | 75.8 | 50.5 |

remaining time consisted of momentary pauses and time when nothing happened. Thus, during the nonbroadcast period, the children spent less time on mathematics than they did during the broadcast period; the teachers also spent less time on mathematics during the nonbroadcast period than did the radio characters during the broadcasts.

**Verbal communication.** Two characteristics of the verbal communications are presented here: participants and amount of speech, and content of the speech. The mathematics lessons had a great deal of verbal communication, involving the children, teacher, and, during the radio broadcasts, the radio itself. On the average, someone was talking 85.3% of the broadcast time, and 63.3% of the nonbroadcast periods with a range from 49.6% to 78.4%. Table 3 presents the percentage of time each of the major participants talked.[1] During the broadcast, the radio talked for 65% of the time, three times the amount of the children. During the nonbroadcast period the teacher similarly dominated the talking. On the average, the teachers talked for 48.7% of the nonbroadcast time, with a range from 32.9% to 63.2%. The children talked during the nonbroadcast period, on the average, 15.8%, with a range from 11.8% to 18.3%. Note that the children talked more during the broadcast periods than during the nonbroadcast periods. The teachers talked on the average 8.3% of the broadcast time, with a range from 4.2% to 18.2%.

When someone was talking, what was it about? The categories differentiating the content of speech are shown in Table 4. For the broadcast column the figures represent the percentage of speech of

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[1] The sum of the percentages reported for each participant is greater than the figure given for the total verbal time because occasionally the children and radio, or children and teacher, talk together. For example, the radio and children talked simultaneously for 8.6% of the broadcast time; thus, 8.6% was added to the verbal time of both the radio and the children.

TABLE 3

Percentage of Lesson Time Spent on Verbalization in Radio Classes

| Participant | Broadcast | Nonbroadcast |
|---|---|---|
| Radio | 65.1 | 0 |
| Teacher | 8.0 | 48.7 |
| Children | 20.8 | 15.8 |

the radio characters; for the nonbroadcast column the figures are a percentage of the teachers' speech.

The content of speech for the radio characters and classroom teacher was quite similar. For both, about two-thirds of the speaking time was on mathematics and one-fifth on other lesson-related instructions, which are instructions about the lesson but not specifically about mathematics.

The radio and the teachers differed on less important characteristics. The teachers spent some verbal time on administration and discipline, while the radio spent about an equal amount of time on "other" content, typically content from the entertainment presentations. Both the radio and teacher gave little praise, but there was no criticism or reprimands. The range for most of the categories during the nonbroadcast periods was not as large as for other characteristics: As a percentage of teacher talk by content, mathematics ranged from 51.3% to 72.1%, other lesson-related instructions from 10.6% to 28.0%, administration from 4.8% to 12.5%, praise from 0% to 1.4%, and discipline from 3.0% to 9.6%.

TABLE 4

Percentage of Verbal Time of Radio During Broadcast and Verbal Time of Teacher During Nonbroadcast

| Content of speech | Broadcast radio | Nonbroadcast teacher | Total |
|---|---|---|---|
| Mathematics | 65.8 | 61.1 | 63.2 |
| Other lesson instructions | 21.1 | 18.9 | 19.8 |
| Administration | .3 | 7.5 | 4.3 |
| Discipline | 0 | 5.5 | 3.1 |
| Praise | .6 | .6 | .6 |
| Criticism or reprimand | 0 | 0 | 0 |
| Other | 12.2 | 6.4 | 9.0 |

One activity included in the "mathematics" category of the preceding discussion was the teacher or radio giving answers to mathematics problems just completed. Providing immediate knowledge of results was an instructional principle the curriculum developers deliberately sought to incorporate into the radio broadcasts. Nineteen percent of the radio characters' speech, or nearly 30% of their speech about mathematics, was used to give the children answers. During the nonbroadcast periods, the teachers gave answers to the children about 9% (with a range from 2% to 15%) of their verbal time, or about 15% of their speech related to mathematics.

The final characteristic of verbal content to be considered is the use of higher thought processes or affect. Although the project did not make an effort to incorporate these characteristics into the lessons, this study included a code to indicate any occurrences. During the radio broadcasts not a single instance of this category was coded; during the nonbroadcast periods, only three occurrences were noted out of the 14 lessons.

**Nonverbal communication.** Many of the important activities in the classroom are nonverbal. In an effort to capture some of these events, the observers dictated relevant information into one of the stereo channels of the tape recorder. The information to be recorded was specified in advance, and recognition of the events to be noted were learned and practiced during the observers' training sessions. The nonverbal actions included the use of visual and simple concrete materials; writing on the chalkboard, in notebooks, or on worksheets; physical responses with the body such as clapping hands in a game, gesturing, or pointing; and correcting notebooks and other lesson-related actions.

The overall division of time during the radio lessons between verbal communications, nonverbal activities, and pauses with nothing happening is shown in Table 5. Sometimes the verbal communications and nonverbal actions occurred simultaneously.

TABLE 5

Percentage of Lesson Time by Category in Radio Classes

| Category | Broadcast | Nonbroadcast | Total |
|---|---|---|---|
| Verbal communications | 85.3 | 63.3 | 72.9 |
| Nonverbal actions | 26.2 | 16.4 | 20.6 |
| Pauses | 1.0 | 23.0 | 13.3 |

TABLE 6

Percentage of Lesson Time According to Type of Nonverbal Action in Radio Classes

| Type of action | Broadcast | Nonbroadcast | Total |
|---|---|---|---|
| Worksheets or notebooks | 18.8 | 8.3 | 12.9 |
| Physical response | 2.2 | 0 | 1.0 |
| Manipulating materials | 0 | .7 | .4 |
| Miscellaneous | .2 | 1.4 | .9 |
| TOTAL | 21.2 | 10.4 | 15.2 |

The radio characters cannot present any nonverbal actions. The nonverbal actions of the children are presented in Table 6. During the broadcast, the nonverbal actions of the children consisted almost entirely of writing on worksheets that were prepared by the project and designed as an integral part of the radio lessons. The only other notable nonverbal action by the children during the broadcast was moving their bodies as part of games. In the nonbroadcast periods the children again wrote on their worksheets; also, they used concrete materials to a limited extent.

Table 7 summarizes the use of visual and other materials during the broadcast and nonbroadcast parts of the radio lessons.[2] Their use during the radio broadcasts was not as great as in the nonbroadcast periods: During the broadcasts, visual materials were used 5.2% of the time and other materials for 1.2%; during the nonbroadcast part of the lesson, the percentages for visual and other materials were 39.0% and 5.7%, respectively. Only two teachers used concrete materials during the nonbroadcast period, one for just 1.5% of the time and the other for 33.7%. The range for using visual materials during the nonbroadcast time was from 19.8% to 63.5%. Thus, the radio broadcasts themselves did not utilize visual and other materials to the extent that might have been expected from the initial intentions of the project staff members. Even in the nonbroadcast periods, concrete materials were not extensively used. However, the project was extremely successful in incorporating visual aids into the nonbroadcast part of the lessons. The use of visual and other materials was consid-

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[2] The data here refer to the time when visual or other materials were in general use. The data in Table 6 refer to specific instances when materials were being manipulated or when worksheets were being written on or pointed to.

TABLE 7

Percentage of Lesson Time That Visual and Concrete Materials Were Used in Radio Classes

| Category | Broadcast | Nonbroadcast | Total |
|---|---|---|---|
| Visual materials | 5.2 | 39.1 | 24.8 |
| Concrete materials | 1.2 | 5.7 | 3.8 |
| TOTAL | 6.4 | 44.8 | 28.6 |

erably greater in the lessons recorded at the beginning of the year when very elementary concepts were being introduced than in the late radio lessons.

It should be noted that although concrete materials were used infrequently during the broadcasts, they were incorporated successfully on those occasions. That is, the project designed instructions that enabled the children to use simple manipulable materials to sort, count, add, and subtract, without any visual demonstration. Concrete materials were successfully incorporated into many broadcast segments near the beginning of the year; nevertheless, there were some difficulties. The materials had to be collected and distributed to the children prior to the broadcast and some materials, most notably bottle caps, tended to be noisy and therefore disruptive.

**Active participation of children.** Perhaps the instructional principle that the project tried most to incorporate into the lessons is that children should be actively involved in the learning process. The level of participation was determined by summing the verbal and nonverbal actions of the children.

As shown in Table 8, the children were more active during the

TABLE 8

Percentage of Lesson Time That Children Were Actively Involved in Radio Classes

| Type of participation | Broadcast | Nonbroadcast | Total |
|---|---|---|---|
| Verbal communication | 20.9 | 15.8 | 18.0 |
| Nonverbal action | 21.2 | 10.4 | 15.2 |
| TOTAL | 42.1 | 26.2 | 33.2 |

broadcast than during the nonbroadcast periods. During the broadcasts the children participated 42.1% of the time, divided approximately evenly between verbal and nonverbal actions. In the nonbroadcast periods the children were actively involved 26.2% of the time, giving an overall participation for the lesson of 33.2%. (There was little variation in the amount of verbal and nonverbal participation of the children in the different classes.)

**Teacher's role during the broadcasts.** The teacher plays an integral role in implementing the project lessons. Although during the broadcasts he relinquishes his major teaching role, he is expected to supervise the children and give assistance where needed. He should ensure that the children are paying attention and responding at the correct time and help those children having difficulty understanding or keeping up with the radio instructions.[3] In the nonbroadcast period the teacher has many specific activities. Before the broadcast he helps the children get ready to listen, hands out the worksheets and any other materials needed during the broadcast, and tunes the radio to the correct station. After the broadcast, he directly instructs the children, using the teacher's guide for suggested activities.

The percentage of broadcast time during which the teachers participated is presented in Table 9. On the average, they were involved 13.3% of the broadcast time, including the verbal and nonverbal participation, with a range from 7.0% to 24.2%. There was slightly more verbal participation, 8.3%, than nonverbal, 5.0%.

### *Teaching With and Without Radio: Some Comparisons*

In this section the preradio classes of 1974 are compared with the late radio lessons of 1975. There are two striking aspects of the preradio classes bearing on their interpretation. First, there was considerable variance among the teachers on virtually all characteristics, more variance than was found in the nonbroadcast part of the radio lessons. Second, five of the six teachers assigned their students to ability groups, often giving the groups different work. Thus, there was variation, not only from teacher to teacher, but from one group to another within each class. The ways in which the radio presentations differed from traditional classes can be summarized in the following brief comparison.

In some ways the preradio classes and radio broadcasts were alike. They were both largely devoted to mathematics, and both had a large

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[3] In the higher grades, especially in classrooms with more than one grade, the project has encouraged the teachers to spend the time during the broadcast with children of the other grades, leaving those children listening to the radio to work without further assistance.

TABLE 9

Percentage of Broadcast Time That Teachers Participated Verbally and Nonverbally

| Teacher | Verbal | Nonverbal | Total |
|---|---|---|---|
| 1 | 8.0 | 8.2 | 16.2 |
| 2 | 6.3 | .7 | 7.0 |
| 3 | 18.2 | 6.0 | 24.2 |
| 4 | 8.7 | 3.8 | 12.5 |
| 5 | 4.2 | 4.0 | 8.2 |
| 6 | 4.4 | 7.5 | 11.9 |
| Mean | 8.3 | 5.0 | 13.3 |

verbal component (although there was more talking during the broadcasts than in the preradio classes) that was dominated by the teacher and radio. Both the teachers and radio characters spent a high percentage of their verbal time asking questions and giving instructions. There was little praise but virtually no criticism or reprimands.

There were many differences between the two sets of lessons. Concerning lesson format, there was more discussion during the radio broadcasts than in the preradio classes. In addition, the broadcasts presented considerable entertainment, whereas in the preradio classes there was none. On the other hand, there was much seat work during the preradio classes, an activity that did not exist during the broadcasts.[4]

The radio lessons eliminated the previously strong practice of grouping the children by ability. Teacher interaction with children of different abilities also changed. During the preradio classes, the teachers interacted more with children in the high ability group, whereas during the broadcasts, the teachers interacted more with children in the low ability group.

The involvement of the children also changed in a number of ways. Their overall participation, including verbal communications and nonverbal actions, increased considerably during the broadcasts. Although the total time the children talked increased, a greater percentage of their verbalization consisted of just one or two words, and they no longer asked questions.

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[4] Recall that the broadcasts incorporated some aspects of seat work in that the children did do written exercises.

The use of visual and other materials was considerably lower during the broadcasts as compared with the preradio classes, although the use of visual materials during the nonbroadcast part of the radio lessons was high.

Table 10 lists some of the pedagogical practices that the project staff members wished to incorporate into the radio lessons, giving the percentage of lesson time for each practice in the preradio classes and during the broadcasts. The project did not specify the exact degree to which these practices should be in evidence but did assume there should be an increase in the use of these practices as compared with the traditional lessons. The project successfully incorporated into the lessons all the practices, except for giving praise and using visual and other materials.

The few differences between the preradio classes and the nonbroadcast period are worth noting. The most consistent difference, one that applied to virtually all of the characteristics analyzed, was the greater variance among the teachers during the preradio classes than during the nonbroadcast periods. For example, the range in time spent on mathematics during the preradio classes was from 42% to 87%, while during the nonbroadcast periods the range was only from 42% to 69%. The large variance during the preradio lessons was not unexpected; however, it was surprising to find so much variance during the nonbroadcast periods, considering that all six teachers worked from a common guide.

The most significant change in the organizational pattern of the classroom in the preradio classes and the nonbroadcast periods concerned the use of ability groups. Whereas in the preradio classes the

TABLE 10

Mean Percentage Lesson Time of
"Desirable" Pedagogical Practices
in the Preradio Classes and Radio Broadcasts

| Practice | Preradio | Broadcasts |
|---|---|---|
| Active participation of children | 24.2 | 42.1 |
| Giving answers | 12.7 | 21.4 |
| Use of visual materials | 20.6 | 5.2 |
| Use of other materials | 10.2 | 1.2 |
| Time on mathematics | 66.7 | 75.8 |
| Use of entertainment | 0 | 25.3 |
| Praise | 1.2 | .6 |
| Pacing (average duration of "states") | 5.7 seconds | 3.5 seconds |

practice of grouping by ability was almost universal, it virtually never occurred during the nonbroadcast periods. Also (as was the case during the broadcasts) the teachers spent more time in the nonbroadcast period with children in the low ability group than they had in the preradio lessons when they had interacted mainly with the high ability students.

There was also some difference between the preradio classes and the nonbroadcast periods in the content of the teacher's speech, indicating a subtle change in the teacher's role. The teacher talked less about mathematics and more about administrative matters and discipline. Thus, although the teacher had definite responsibilities for teaching mathematics during the nonbroadcast periods, his role as a teacher was somewhat diminished in favor of an increased role as a manager of the classroom.

### *Correlations Between Classroom Variables and Student Achievement*

This study sought to describe in detail the typical events or activities in classrooms that used the radio lessons and to compare these lessons with traditional classes taught without the use of radio. Since many variables were analyzed and the project had administered pretests and posttests to the classes in this study, it seemed appropriate to determine whether any of the variables were significantly correlated with student achievement. Although statistically significant correlations were found, the results must be treated cautiously because of the small number of classes. Separate comparisons were made for the data of 1974 and 1975.

The six classes were ranked according to the test scores for both 1974 and 1975; separate rankings were made based on each classroom characteristic being studied in each year. A correlation coefficient was then calculated between the ranking based on the posttest scores and the ranking based on each characteristic.

Of all the rankings checked, there were only four relations significant at the .1 significance level or better—three for the preradio classes and one for the nonbroadcast period. In the 1974 preradio classes there was a positive correlation between the rankings based on posttest scores and the percentage of lesson time the children participated ($r = .77$). An identical correlation was found between the posttest scores and the percentage of lesson time the children talked ($r = .77$). There was a negative correlation between the ranking of the posttest scores and that based on the percentage of lesson time that some of the children were left with nothing to do ($r = -.94$).

During the nonbroadcast period there was a significant correlation between the ranking based on the 1975 posttest and the ranking based on the time in minutes that was devoted to mathematics ($r = .89$). The time in minutes spent on mathematics was calculated by multiplying the duration of the nonbroadcast period by the percentage of that period that was devoted to mathematics. This finding is interesting because there was not a high correlation between the posttest and the length in minutes of the postbroadcast period, or between the posttest and the percentage of the postbroadcast period that was devoted to mathematics.

Although few significant correlations were found, those that did occur are consistent with our expectations. For example, the positive relation between posttest scores and the amount of children's participation supports the staff's view that increasing student participation should increase learning. The correlation between student achievement and the percentage of time the children talked might not be expected, except that verbalization makes up the participation index along with the time spent on nonverbal activities. The final finding for the preradio classes—a negative correlation between the posttest and the percentage of lesson time in which at least some children were left without an assignment—is logical. If some children are left on a regular basis with nothing to do, lower test scores are to be expected.

The finding for the nonbroadcast period that the amount of time in minutes spent on mathematics is positively correlated with posttest scores also is intuitively reasonable and supports the notion that the teacher does make a difference. The finding indicates that if the teacher devotes more time to mathematics, ensuring that a high percentage of that time is actually spent on mathematics, the children may learn more.

### *Development of the Radio Programs: Classroom Activities During the Early and Late Broadcasts*

All of the results attributed to the broadcasts throughout this report have been based on data from radio lessons at the end of the 1975 school year. These lessons were used because they represent an evolved and reasonably stable form; the lessons produced in subsequent years have not changed to the degree that occurred during the first year the lessons were being developed.

The classroom activities during the broadcasts at the beginning and end of the year were alike in many ways—they were largely about mathematics and interspersed with entertainment presentations. Nevertheless, the activities differed in several important ways. A comparison of the activities in the early and late lessons will illustrate the evolution of the lessons during the school year.

The major changes in the activities during the broadcasts from the beginning to the end of the year consisted of increased time for mathematics (including the time for giving answers), an increase in the verbal and nonverbal participation by the children, and a decrease in the overall verbalization and the use of visual and other simple materials.

The changes basically reflect the evolution of the lessons during the year and were consciously made as a result of feedback from the classroom. It is possible that some of the differences may reflect the increased maturity of the children and their greater familiarity with learning by radio during the year. Nevertheless, it is the opinion of the senior project staff members that the changes are largely the result of deliberate efforts to use radio more effectively and that, should the first-grade lessons be completely revised, the new lessons for the beginning of the year would result in classroom activities that resemble those reported here for the end of 1975.

## 4. CONCLUSIONS

Upon the completion of a study such as this one, many questions arise. Did it produce the results initially hoped for? How do the findings compare with data obtained elsewhere? If the study were to be repeated, what changes would be suggested?

The study accomplished what it set out to do. First, it documented the use of an inexpensive instructional technology in terms of activities that can be elicited from participants. The study showed there can be special advantages in using instructional radio in comparison with instruction by typical teachers. In this project the broadcasts devoted a high percentage of the time to mathematics (even though there were many entertainment presentations), actively engaged the students, and incorporated the use of visual and other materials in ways that could be understood by first-grade children. Finally, the broadcasts reduced variations in lesson presentation and classroom activities and thus helped to ensure a greater consistency in achievement, at a higher level, for all children.

Second, the study measured the extent to which the project incorporated certain principles of instruction into the radio broadcasts. Compared with traditional classes, the radio broadcasts spent more time on mathematics, resulted in greater participation by the children, gave more answers to mathematics problems, included entertainment, and had a more rapid pace. The broadcasts did not give more praise nor use visual or other materials to the extent used in traditional classes.

Third, some unanticipated effects were recorded. An established practice of using ability groups was eliminated, in the nonbroadcast periods as well as in the broadcasts. Also the teacher's interaction with children of different ability shifted dramatically—from greater attention to children in the top ability group in the preradio classes to more time spent with children in the low ability group during both parts of the radio lessons.

Fourth, the study isolated four variables (student participation, student verbalization, time with nothing to do, and time devoted to mathematics content) that showed significant correlations with student achievement. It seems likely that these are some factors, together with the meticulous development and organization of mathematics content, that help account for the outstanding achievement gains of the children in the radio classes.

Fifth, the study found that the broadcasts at the end of the year were significantly different from those at the beginning—there was increased time for mathematics, an increase in the verbal and nonverbal participation of the children, and a decrease in the overall verbalization and the use of visual and other materials. The contrast between the early and late broadcasts stresses the fact that not all first-grade radio broadcasts about mathematics are the same, not even within a single project. Thus, the success of the project in raising student achievement is probably not due to any special or unique qualities of radio but to the way in which the medium is used.

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# Chapter 7

# RADIO EDUCATION AND STUDENT REPETITION IN NICARAGUA

DEAN T. JAMISON
*The World Bank*

IN MOST low-income countries, students who have repeated one or more grades occupy a substantial portion of the available elementary-school places. In addition to the psychological and perhaps economic cost to the child that this repetition entails, there is a penalty to the school system: Class sizes tend to increase, school budgets rise, and access to any schooling at all extends more slowly to hitherto excluded populations. It is thus surprising that the literature contains few studies indeed of the determinants of student failure and repetition[1] and that project evaluations fail to report on the impact on repetition of the interventions they assess.[2] The literature that is

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[1] I use *failure* to denote a student's not being promoted to the next grade and *repetition* to denote his both failing and reenrolling the subsequent year.

[2] A special issue of the *Bulletin of the International Bureau of Education* (IBE, 1969) contains an annotated bibliography concerning *wastage* in education; the term *wastage* includes both dropout and repetition in an educational system. Only a few of the books and articles that the special issue annotated dealt in any way with causes of repetition; of the few studies cited, most dealt with European countries (Belgium, France, Germany, Italy, and the USSR) and only a few with low income countries (India and Thailand). Wolff (1970) provides a more recent study of determinants of repetition with data from

available concerning repetition suggests, plausibly enough, that given a school system's promotion policy, a child's performance and attendance at school and the economic conditions of his background play important roles; this literature is more suggestive than definitive, more qualitative than quantitative.

Though little is known about the determinants of repetition, a good deal of statistical information is available concerning its extent (IBE, 1972; UNESCO, 1974). To give a sense of the magnitude of the problem, Table 1 shows recent repetition figures for a number of Latin American countries. The numbers there are high indeed, though typically only half as high for the fourth grade as for the first. It is the magnitude of these numbers, and their importance for the economics of school systems, that suggests the importance of increased attention to understanding the causes of repetition and the impact of educational interventions on its extent.

My purpose in this chapter is to analyze the impact of the Radio Mathematics Project on repetition rates. This analysis provides information not only on the project's effect on repetition, but also on the other determinants of repetition and how to assess them. To undertake the analysis, I construct a statistical model that first predicts posttest performance and then uses posttest performance with other variables to predict student failure, repetition, and reenrollment. The chapter is organized as follows. Section 1 briefly summarizes previous evaluations of the Radio Mathematics Project. Section 2 then describes the model that I use to assess the project and the data used in the model. Section 3 contains the statistical results and Section 4 discusses their economic implications. Section 5 provides a brief conclusion.

## 1. PREVIOUS EVALUATIONS

The Radio Mathematics Project evaluated student cognitive performance at the first-grade level in both the 1975 and the 1976 school years (Nicaraguan school years run from February through November). The 1975 evaluation was preliminary: There was no random assignment of classrooms to radio versus control, the radio curriculum was still being developed, the sample size was relatively

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Brazil. The paucity of studies on determinants of repetition contrasts with an extensive literature on determinants of dropping out, much of which is annotated in the IBE bibliography and well summarized in Beirn, Kinsey, and McGinn (1972). Jallade (1977) and Jamison and Lau (1978, chap. 8) have provided evidence that the economic *consequences* of repetition are substantial; their work suggests that the internal rate of return to investment in schooling tends to be highly sensitive to the repetition rate.

TABLE 1

Repetition Rates in Latin America[a]

| Countries | Year | Grade 1 | Grade 4 |
|---|---|---|---|
| CENTRAL AMERICA AND CARIBBEAN | | | |
| Costa Rica | 1972 | 11 | 4 |
| Cuba | 1971 | 41 | 27 |
| Dominican Republic | 1969 | 33 | 11 |
| El Salvador | 1972 | 16 | 5 |
| Nicaragua | 1971 | 15 | 8 |
| Panamá | 1972 | 21 | 10 |
| SOUTH AMERICA | | | |
| Argentina | 1969 | 23 | 9 |
| Chile | 1972 | 13 | 8 |
| Colombia | 1972 | 22 | 10 |
| Ecuador | 1972 | 16 | 10 |
| Guyana | 1971 | 17 | 7 |
| Paraguay | 1968 | 26 | 9 |
| Perú | 1970 | 25 | 12 |
| Uraguay | 1972 | 30 | 14 |
| Venezuela | 1965 | 24 | 14 |

*Note.* From UNESCO Statistical Yearbook (1974, pp. 203–204).

[a] The entries in the table are repetition rates, expressed in percent, where repetition is calculated by dividing the number of repeaters by the enrollment for the same year.

small, and, for some of the schools, the occasional presence of project personnel for formative evaluation may have affected the results. Nonetheless, reasonably good data were collected, and Searle, Friend, and Suppes (1976, chap. 9) report on an analysis of the effect of exposure to radio on mathematics achievement. They found that students who had had radio lessons scored about 67% correct on the end-of-year test, while students who had had no radio lessons scored only about 55%; this difference is highly statistically significant and reflects a difference of about half a standard deviation.

The evaluation of the project based on the 1976 data (reported in chap. 3 of this book) provides more conclusive results than do evaluations based on the 1975 data. The sample size was larger, the students were randomly assigned to treatment and control groups, and, perhaps most important, a tested and revised version of the curriculum was in use. Table 2 (reprinted from chap. 3) contains some of the more important results. Perhaps because the curriculum had been

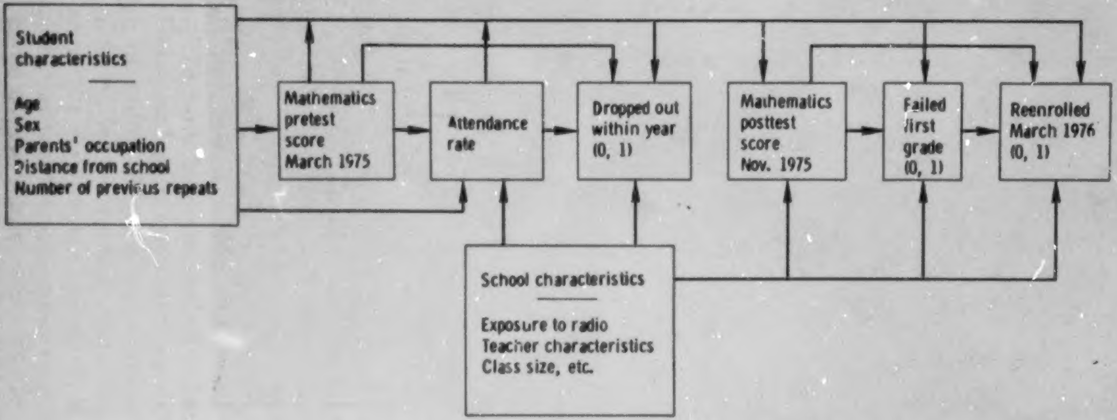
Student characteristics
Age
Sex
Parents' occupation
Distance from school
Number of previous repeats
Mathematics pretest score March 1975
Attendance rate
Dropped out within year (0, 1)
Mathematics posttest score Nov. 1975
Failed first grade (0, 1)
Reenrolled March 1976 (0, 1)
School characteristics
Exposure to radio
Teacher characteristics
Class size, etc.

FIGURE 1. Causal model of radio's effect on learning, dropout propensity, and failure propensity.

TABLE 2

Results of 1976 First-grade Posttest in Mathematics

| | Experimental (radio) | Control |
|---|---|---|
| Number of classes | 30 | 23 |
| Number of students | 571 | 438 |
| Number of test items | 84 | 84 |
| Mean item score[a] | 65.6 | 40.6 |
| Standard deviation | 19.9 | 18.9 |

[a] Percent correct.

improved, the results show a larger difference in favor of the radio students than was found in the 1975 data. On the posttest, the radio students performed at a level a full 1.26 standard deviations higher than the controls; they answered half again as many questions correctly.

In this chapter I extend the scope of the evaluations just described by examining the effect of the project on students' propensity to repeat or drop out. At the time of writing, data on these outcomes were unavailable for the 1976 school year; I therefore use data from 1975, when the effect of the project on achievement test scores was less pronounced.

## 2. THE MODEL AND DATA

### *The Model*

Figure 1 diagrams the basic structure of the model I use to assess the impact of radio on the various dependent variables of interest. The two large boxes, labeled "student characteristics" and "school characteristics," contain the exogenous variables of the model; the six smaller boxes contain the six endogenous variables arranged as a recursive system. With six endogenous variables there are six regression equations in the model, and the arrows leading into each box containing an endogenous variable indicate the independent variables to be used in the equation to predict that endogenous variable. Note that the recursive structure of the model allows one to estimate indirect as well as direct effects of one variable on another. For example, the diagram indicates that radio may influence posttest score directly, or indirectly through whatever influence it has on attendance rate and the subsequent direct influence of attendance rate on posttest. Similar chains of indirect and direct influence allow estimation of the effect of radio on failure and reenrollment.

Economists label analysis of the determinants of achievement test scores "educational production function" studies; Lau (1978) provides an excellent discussion of the methods used in educational production-function analysis and observes that most such analyses assume a single output.[3] The regression indicated in Figure 1 in which posttest score is the dependent variable is an example of traditional educational production-function analysis; however, the model as presented in fact has two indicators of student performance—his posttest score and whether he failed first grade—and is thus properly considered a multiple-output production model. Viewed from a production perspective, however, the model differs from standard multiple-output models in that one output, posttest score, is both a final output and an intermediate output because of its effect on propensity for failure.

Three of the dependent variables—within-year dropout, failure, and reenrollment—are dichotomous, that is, they can take on only one of two possible values (indicated in Fig. 1 as 0 or 1). Special statistical techniques are required to handle regressions with dichotomous dependent variables, and before I discuss further the variables in the model, I shall describe the regression specifications that will be used.

The regressions with continuous dependent variables—those for pretest and posttest scores and the one for attendance—are specified in the standard way:

$$Y = b_0 + \sum b_i X_i ,$$

where $Y$ is the dependent variable, the $X_i$ s are the independent variables, and the $b_i$ s are parameters to be estimated (by ordinary least squares, assuming independence of the error terms in the equations of the model).

For the endogenous variables that are dichotomous the model specifies a functional form, the parameters of which are to be estimated, that gives the conditional probability that the value of the dependent variable $Y$ is 1, given the values of the independent variables. The model used assumes that if a weighted sum of the independent variables, $\sum b_i X_i$, exceeds an (unknown) critical value $C$, then

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[3] Wells's (1974, chap. 8) study of the determinants of several dimensions of comprehension of economics is one previous study of educational production in which multiple outputs were explicitly considered.

$Y = 1$; otherwise $Y = 0$. It assumes $C$ to be randomly distributed, and slightly different models result from different assumptions about the distribution for $C$; in this paper I use what is perhaps the most common assumption, that $C$ follows the logistic distribution. The resulting model for predicting the dependent variable is known as the *logit* model. Given the functional form of the logistic distribution, it can be shown that

$$\text{prob}(Y = 1 \mid X_1, \cdots, X_n) = 1/[1 + \exp(-\textstyle\sum b_i X_i)] .$$

The parameters of the model, the $b_i$, can be estimated by maximum-likelihood methods, as can estimates of their statistical significance. As with ordinary regression analysis, the larger the value of $b_i$, the greater will be the change (in this case) in the probability of $Y$ for a given change in $X_i$.[4]

### The Data

As previously indicated, the data are from the 1975 school year and come from schools in Masaya Department, Nicaragua, which is about 30 kilometers south of Managua. The participating schools represent a range of environments—from urban to quite rural—and the students attending them are likewise diverse. While the allocation of radio lessons to classrooms was nonrandom, the students receiving radio lessons differed only slightly from the controls. However, radio students were much more likely to come from an agricultural family than were nonradio students; in addition, they had larger class sizes and lower pretest scores. The 1975 school year was a developmental period that entailed frequent visits by project staff to the participating radio schools. Plausibly, therefore, a Hawthorne effect could have accounted for the superior performance of the radio students; however, the project provided radio lessons with no direct supervision whatever to a few schools in the adjacent Department of Granada, and students in those schools also performed much better than did the controls. Searle et al. (1976) discuss these and other aspects of the data in much more detail.

Table 3 lists and defines the variables used in this analysis, presents their means and standard deviations, gives the means for the radio and nonradio subgroups, and shows the number of students for

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[4] Kohn (1976) provides a valuable overview of logit and related approaches to estimation of models to predict choice probabilities or to discriminate among discrete sets of outcomes.

TABLE 3

Means and Standard Deviations of the Variables

| Variable | | N[a] | Mean | Standard deviation | Subsample means | |
|---|---|---|---|---|---|---|
| | | | | | Radio group | Nonradio group |
| | Student characteristics | | | | | |
| **MALE** | 1 for male students, 0 for female | 943 | .500 | .500 | .487 | .525 |
| **AGE** | Age of student, in years | 853 | 8.54 | 1.04 | 8.51 | 8.60 |
| **AGOCC** | 1 if student's family is employed in agriculture | 926 | .198 | .398 | .257 | .085 |
| **DIST** | Distance in kilometers of student from school | 863 | .759 | .876 | .827 | .596 |
| **NRPT** | Number of times student repeated first grade | 951 | .480 | .630 | .462 | .512 |
| | School characteristics | | | | | |
| **RURAL** | 1 if student attended rural school | 950 | .361 | .480 | .440 | .792 |
| **USH** | 1 if student attended urban school with shifts | 950 | .537 | .499 | .560 | .494 |
| **UNOSH**[b] | 1 if student attended urban school without shifts | 950 | .102 | .303 | 0 | .298 |
| **CLSIZ** | Student-to-teacher ratio in student's classroom | 950 | 46.7 | 12.0 | 49.0 | 42.2 |
| **RADIO** | 1 if student's class received radio instruction | 950 | .657 | .475 | | |
| **TAGE** | Age of student's teacher, in years | 950 | 32.0 | 8.57 | 31.3 | 33.4 |
| **TED** | Education of student's teacher, in years | 950 | 11.2 | 1.38 | 11.7 | 10.5 |
| **TEXP** | Teaching experience of student's teacher, in years | 950 | 11.5 | 8.46 | 11.0 | 12.5 |

(TABLE 3, cont.)

| Variable | | $N^a$ | Mean | Standard deviation | Subsample means | |
|---|---|---|---|---|---|---|
| | | | | | Radio group | Nonradio group |
| | Endogenous variables | | | | | |
| **PRE** | Student pretest score in mathematics | 577 | 20.3 | 4.65 | 19.8 | 21.2 |
| **POST** | Student posttest score in mathematics | 422 | 55.8 | 13.5 | 59.2 | 50.2 |
| **ATTAV** | Student's average attendance in days per month | 911 | 14.1 | 3.32 | 14.3 | 15.1 |
| **DROP** | 1 if student dropped out during school year | 665 | .140 | .347 | .173 | .074 |
| **FAIL** | 1 if student failed grade | 885 | .453 | .498 | .462 | .438 |
| **RENRL** | 1 if student reenrolled in subsequent school year | 885 | .788 | .409 | .803 | .763 |

*Note.* All values are reported to three significant digits.

[a] $N$ is the number of students for whom information on the indicated variable was available.

[b] As there were no rural schools with multiple sessions or shifts, each student has a value of 1 for exactly one of the variables **RURAL**, **USH**, and **UNOSH**.

whom information is available on the particular item. It is evident from Table 3 that there is a substantial variation in the number of students for whom each particular item of information is available. For this reason the analyses reported in the next section were also undertaken with the subsample of students for whom all data were available, as well as other subsamples. The broad pattern of results reported in Section 3 remains unchanged.

## 3. RESULTS

I divide the discussion of the results of this analysis into two parts. The first part discusses the determinants of student *performance*; the dependent variables considered in that part are pretest score, posttest score, and failure propensity. The second part discusses determinants of *demand* for schooling;[5] the relevant dependent variables are school attendance rate, within-year dropout propensity, and propensity to reenroll for the subsequent school year.

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[5] Jamison and McNally (1975) provided an earlier analysis of the demand for schooling in Nicaragua with data gathered as a baseline for evaluation of the Radio Mathematics Project. Searle, Sheehan, González, and George (in chap. 8 of this volume) provide a more detailed analysis of these baseline data and a thorough description of the process and patterns of student flows in Nicaraguan schools.

*Determinants of Student Performance*

There is by now an extensive literature on factors determining student performance as measured by standardized achievement tests. Lau (1978) provides an excellent overview of the conceptual and technical methods and problems of this "educational production" literature; Jamison, Suppes, and Wells (1974, pp. 1–67) and Simmons and Alexander (1976) review its empirical findings. However, as I indicated in the introductory paragraphs of this chapter, almost no research has been undertaken in which the measure of performance is whether the student passes or fails. One reason for this is that most research on educational production has been undertaken with data from high-income countries where promotion is virtually automatic; another reason, perhaps, is that the subjective nature of a teacher's decision to fail a student may seem to provide a less valid dependent measure than an objective test score. For whatever reason, the literature is scant on the determinants of failure despite the major economic importance of failure rates in educational planning.

This part contains estimations of three educational production functions, in which the performance measures are the student's pretest score, his posttest score, and whether he failed first grade. Figure 1 shows these variables in their proper causal sequence in the model.

**Pretest score.** Table 4 shows the estimated regression coefficients for the determinants of pretest score in mathematics. Only two of the

TABLE 4

Regression Determinants of Pretest Scores

| Variable | Subsample mean | Coefficient | *t* value |
|---|---|---|---|
| **MALE** | .512 | −.309 | −.69 |
| **AGE** | 8.61 | .752 | 7.5 |
| **AGOCC** | .222 | −.422 | −.86 |
| **DIST** | .791 | −.131 | −.58 |
| **NRPT** | .516 | 1.75 | 5.7 |
| Constant | | 13.1 | |

*Note.* Dependent variable = **PRE**; subsample mean (**PRE**) = 20.1; subsample *SD* (**PRE**) = 4.8; subsample size = 473; multiple $R^2$ = .17. All values are reported to three significant digits.

variables examined affect the pretest score—the student's age and the number of times he has repeated first grade. Older students perform better, as do those who have repeated. Prior exposure to the mathematics curriculum would seem to more than compensate for the (presumably) lower ability of the repeaters, a finding somewhat at odds with that of Carnoy, Sack, and Thias (1977) who found the number of primary-school repeats to be negatively related to secondary-school performance.

**Posttest score.** Table 5 shows the estimated production function for performance on the mathematics posttest. Since the pretest score is controlled for and all data are available on an individual-student basis, this data set allows better estimation of the effects of various teacher and school variables than do most educational production-function studies. In contrast to the results on determinants of pretest score, the number of times the student has repeated is no longer significant, and the student's age is only marginally so. Pretest score is a powerful determinant of posttest performance, as all previous research on the matter would suggest. Larger class sizes result in *better* student performance, which, though counterintuitive, is consistent with a mixed pattern of findings in the literature (Jamison et al., 1974; Haddad, 1977). As one would expect, more frequent student attendance results in better performance;[6] teacher's education level and experience are insignificant, and, controlling for experience, older teachers have lower peformance. Students from rural farming families do less well.

Perhaps the most striking aspect of Table 5 is the magnitude and significance of the coefficient for the effect of radio. Exposure to the radio mathematics lessons can far more than compensate for a child's agricultural origins and can more than compensate for his performance falling one and a half standard deviations behind on the pretest. The radio lessons appear to have no differential benefit for either good or poor students, as the regression coefficient for the interaction between pretest score and exposure to radio was insignificant (in a regression not reported here).

**Failure propensity.** Table 6 shows the maximum-likelihood estimates of the coefficients in the logit equation to predict end-of-year failure. Each child's teacher determines whether the child passes or fails, based on the child's performance on end-of-year tests prepared by the teacher in five subjects, one of which is mathematics. In interpreting the regression results it should be borne in mind that the

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[6] Ziegler (1928) reviewed and extended early work on the importance of attendance in determining student performance, and, much more recently, Wiley (1973) and Wiley and Harnischfeger (1974) reemphasized the importance of attendance with valuable empirical and policy studies.

TABLE 5

Regression Determinants of Posttest Scores

| Variable | Subsample mean | Coefficient | $t$ value |
|---|---|---|---|
| Student characteristics | | | |
| **MALE** | .537 | .866 | .60 |
| **AGE** | 8.57 | .788 | 1.9 |
| **AGOCC** | .185 | −5.32 | −2.6 |
| **DIST** | .696 | −.323 | −.39 |
| **NRPT** | .522 | .782 | .54 |
| School characteristics | | | |
| **USH** | .641 | −1.26 | −.53 |
| **UNOSH** | .0444 | −.453 | .09 |
| **CLSIZ** | 44.3 | .232 | 2.4 |
| **RADIO** | .752 | 10.1 | 6.4 |
| **TAGE** | 31.5 | −.474 | 2.0 |
| **TED** | 11.2 | −.826 | −.95 |
| **TEXP** | 11.1 | .297 | 1.5 |
| Endogenous variables | | | |
| **PRE** | 20.4 | 1.21 | 8.6 |
| **POST** | | | |
| **ATTAV** | 15.2 | .687 | 3.0 |
| **DROP** | | | |
| **FAIL** | | | |
| **RENRL** | | | |
| Constant | | 20.0 | |

*Note.* Dependent variable = **POST**; subsample mean (**POST**) = 57.8; subsample *SD* (**POST**) = 12.2; subsample size = 270; multiple $R^2$ = .40. All values are reported to three significant digits.

teacher was *unaware* of the child's score on the project-administered mathematics test, which is the test score used in the analysis here. Table 6 clearly indicates that the student's posttest score is a strong determinant of likelihood to fail; it can be computed that, other things being equal, a student scoring 5 points higher than the mean on the posttest will have his probability of failure decreased by .11 from what it would be had he scored at the mean. The table also suggests sex discrimination: Male students are less likely to fail than are females.

(Observations in the classrooms also indicated teacher favoritism for male students.) More regular attendance decreases a child's probability of failure, though the coefficient is statistically insignificant. Exposure to radio in itself has no significant effect on the likelihood that a child will fail; the effect of radio is, instead, indirect—through its impact on achievement and achievement's subsequent impact on failure propensity. Despite this conclusion that poor achievement is an

TABLE 6

Regression Determinants of
End-of-year Failure

| Variable | Subsample mean | Coefficient | Asymptotic *t* value |
|---|---|---|---|
| Student characteristics | | | |
| **MALE** | .539 | −1.39 | −3.7 |
| **AGE** | 8.57 | .044 | .34 |
| **AGOCC** | .182 | .455 | 77 |
| **DIST** | .697 | .063 | .30 |
| **NRPT** | .524 | −.687 | −2.1 |
| School characteristics | | | |
| **USH** | .643 | .503 | .75 |
| **UNOSH** | .0446 | 2.82 | 2.0 |
| **CLSIZ** | 44.2 | .011 | .38 |
| **RADIO** | .751 | .484 | .72 |
| **TAGE** | 31.6 | −.201 | −2.3 |
| **TED** | 11.2 | .256 | 1.1 |
| **TEXP** | 11.1 | .177 | 2.3 |
| Endogenous variables | | | |
| **PRE** | 20.4 | −.019 | −.42 |
| **POST** | 57.8 | −.114 | −5.5 |
| **ATTAV** | 15.2 | −.100 | −1.2 |
| **DROP** | | | |
| **FAIL** | | | |
| **RENRL** | | | |
| Constant | | 7.940 | 1.57 |

*Note.* Dependent variable = **FAIL**; subsample mean (**FAIL**) = .271; subsample *SD* (**FAIL**) = .44; subsample size = 269. Regression characteristics: Dichotomous dependent variable, logit specification, maximum-likelihood estimation. Chi-square of estimate (8 degrees of freedom) = 94.2. All values reported to three significant digits.

important determinant of failure, it is nonetheless possible, as Robinson (1977) has suggested, that lack of places in higher grades can cause teachers to fail students and that relative achievement is the screening mechanism.[7]

We shall return in Section 4 to discussion of the overall magnitude of radio's impact (both direct and indirect) on failure and other variables.

### *Determinants of Demand for Schooling*

This subsection examines the determinants of three indicators of students' demand for schooling in Nicaragua—their rate of attendance in school, their propensity to drop out during the school year, and, given that they completed the year, their propensity to reenroll the subsequent school year.[8]

**Attendance.** As previously noted, attendance is itself an important determinant of student learning; Table 7 reports on the factors influencing attendance rate, here defined as the number of days per month that the child attended school averaged over that portion of the school year during which the child was enrolled. The table identifies a number of variables that significantly affect attendance; among school variables, both teacher experience and enrollment in a single-shift urban school increase attendance rates, while large class sizes decrease them. Being from an agricultural family tends to *increase* attendance, a finding that differs from results of early research in the United States on determinants of attendance (Folks, 1920; Reavis, 1920); more recent studies with U.S. data (Maynard & Murname, 1978) also indicate that improving the economic environment of the home improves attendance rates.

**Within-year dropout propensity.** Table 8 shows the determinants of within-year dropout propensity as estimated from these data. The coefficient of attendance is highly significant at standard levels; however, more frequent attendance increases the likelihood that a child would drop out, contrary to natural expectations. Students with higher pretest scores are less likely to drop out, though this effect is

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[7] Regression analyses of the determinants of end-of-year failure were also undertaken for the radio and control groups separately. For both groups, posttest score had a strong and statistically significant impact on reducing failure propensity, but the magnitude of the effect was higher within the radio group. No other determinants of failure were statistically significant in the control group, though a substantial number, particularly teacher characteristics, were significant for the radio group.

[8] Each of the regressions reported in this subsection suffers from the defect that the sample is only of children who entered school; the results for dropout and reenrollment propensity are thus contingent on the child's initially having enrolled. Shortlidge (no date), in a valuable study of school attendance in rural India, uses a logit model to estimate the probability that a child attends school at all.

TABLE 7

Regression Determinants of Attendance Rate

| Variable | Subsample mean | Coefficient | *t* value |
|---|---|---|---|
| | Student characteristics | | |
| **MALE** | .509 | .313 | 1.0 |
| **AGE** | 8.64 | .103 | 1.0 |
| **AGOCC** | .230 | 2.40 | 4.5 |
| **DIST** | .806 | .264 | 1.6 |
| **NRPT** | .504 | .717 | 4.9 |
| | School characteristics | | |
| **USH** | .605 | −1.12 | −1.3 |
| **UNOSH** | .055 | 5.08 | 4.4 |
| **CLSIZ** | 45.4 | −.114 | −4.0 |
| **RADIO** | .765 | .032 | 1.5 |
| **TAGE** | 31.8 | −.193 | −1.6 |
| **TED** | 11.3 | −.552 | −1.7 |
| **TEXP** | 11.3 | .067 | 1.1 |
| | Endogenous variables | | |
| **PRE** | 20.1 | .007 | .20 |
| **POST** | | | |
| **ATTAV** | | | |
| **DROP** | | | |
| **FAIL** | | | |
| **RENRL** | | | |
| Constant | | 27.7 | |

*Note.* Dependent variable = **ATTAV**; subsample mean (**ATTAV**) = 14.87; subsample *SD* (**ATTAV**) = 3.49; subsample size = 456; multiple $R^2$ = .26. All values are reported to three significant digits.

only marginally significant. Students from agricultural families are more likely to drop out, though, controlling for that, students in rural schools are more likely to stay through the year.

**Reenrollment.** Table 9 shows the determinants of student reenrollment. Students who fail are significantly less likely to reenroll than are those who pass, a result supportive at the micro-level of Levy's (1971) finding that countries with higher failure rates had higher dropout rates. Controlling for failure, higher posttest scores

TABLE 8

Regression Determinants of Within-year Dropout

| Variable | Subsample mean | Coefficient | Asymptotic *t* value |
|---|---|---|---|
| Student characteristics | | | |
| **MALE** | .513 | −.261 | −.65 |
| **AGE** | 8.61 | −.074 | −.54 |
| **AGOCC** | .260 | 1.09 | 2.1 |
| **DIST** | .782 | .299 | 1.5 |
| **NRPT** | .504 | .015 | −.049 |
| School characteristics | | | |
| **USH** | .580 | 2.30 | 2.3 |
| **UNOSH** | .0560 | 3.21 | 1.8 |
| **CLSIZ** | 45.6 | .033 | .86 |
| **RADIO** | .759 | .653 | .66 |
| **TAGE** | 31.5 | −.033 | −.28 |
| **TED** | 11.2 | .153 | .45 |
| **TEXP** | 10.8 | .019 | .19 |
| Endogenous variables | | | |
| **PRE** | 20.0 | −.065 | −1.63 |
| **POST** | | | |
| **ATTAV** | 15.3 | .237 | 3.75 |
| **DROP** | | | |
| **FAIL** | | | |
| **RENRL** | | | |
| Constant | | −10.2 | |

*Note.* Dependent variable = **DROP**; subsample mean (**DROP**) = .126; subsample *SD* (**DROP**) = .33; subsample size = 357. Regression characteristics: Dichotomous dependent variable, logit specification, maximum-likelihood estimation. Chi-square of estimate (12 degrees of freedom) = 71.2. All values reported to three significant digits.

### TABLE 9

### Regression Determinants of Reenrollment Subsequent Year

| Variable | Subsample mean | Coefficient | Asymptotic *t* value |
|---|---|---|---|
| Student characteristics | | | |
| **MALE** | .527 | −.380 | −.799 |
| **AGE** | 8.58 | −.172 | −1.13 |
| **AGOCC** | .187 | 1.10 | 1.11 |
| **DIST** | .697 | .220 | .541 |
| **NRPT** | .523 | −.248 | −.640 |
| School characteristics | | | |
| **USH** | .633 | −.111 | −.12 |
| **UNOSH**[a] | | | |
| **CLSIZ** | 44.3 | .080 | 1.7 |
| **RADIO** | .744 | −.525 | −.75 |
| **TAGE** | 31.7 | −.065 | −.78 |
| **TED** | 11.2 | .181 | .50 |
| **TEXP** | 11.2 | .074 | .82 |
| Endogenous variables | | | |
| **PRE** | 20.4 | −.126 | −1.9 |
| **POST** | 57.9 | .047 | 2.2 |
| **ATTAV** | 15.2 | .022 | .23 |
| **DROP** | | | |
| **FAIL** | .275 | −1.26 | −2.5 |
| **RENRL** | | | |
| Constant | | .302 | .45 |

*Note.* Dependent variable = **RENRL**; subsample mean (**RENRL**) = .897; subsample *SD* (**RENRL**) = .304; subsample size = 262. Regression characteristics: Dichotomous dependent variable, logit specification, maximum-likelihood estimation. Chi-square of estimate (15 degrees of freedom) = 29.2. All values are reported to three significant digits.

[a] **UNOSH** was eliminated from the regression because of its collinearity with the dependent variable.

lead to higher probabilities of reenrollment; but, interestingly enough, higher pretest scores lead to a lower probability of reenrollment. This suggests that, holding end-of-year performance constant, the more a child has gained during the year, the more likely he is to reenroll the next year.

## 4. ECONOMIC IMPLICATIONS

My principal purpose in this chapter has been to assess the impact of radio and other variables on several indicators of a student's school performance, particularly on the probability that he will fail the first grade. The preceding section presented the results of this analysis. However, since failure and repetition rates have such important implications for the cost of a "graduate" from each grade or each cycle of a school system, I feel it worth including a preliminary analysis of the economic impact of the Radio Mathematics Project through its effect on these variables.

The introduction of radio necessarily raises the cost per student per year (assuming no simultaneous increase in class size or other resource saving); however, if introducing radio reduces the probability of a student's failing, it may well reduce the cost per first-grade graduate even though it raises the cost per student. Let $f$ be the probability that a child fails first grade, let $C_s$ be the cost per student per year, and let $C_g$ be the cost per graduate. It is easy to compute that $C_g = C_s/(1-f)$. In order to compare the cost per graduate with radio to the cost per graduate without radio it is, then, necessary to have values of $C_s$ and $f$ with and without radio.

**Cost.** A recent assessment of the education sector in Nicaragua (Academy for Educational Development, 1975) estimates the cost per primary student per year to be \$54.00. Jamison and McAnany (1978, chap. 4) estimate the cost per student in the project to be about \$3.00 per year, assuming moderate usage of the system. (The *marginal* cost per student is about \$1.65 per year, allowing scope for substantial reduction in average costs as usage expands.) We thus have $C_s$ = \$54.00 without radio and \$57.00 with radio.

**Effectiveness.** To estimate the effect of the project on the probability that a student fails, one must take into account the direct effect and all of the indirect effects indicated in Figure 1. This can be done, using the estimated regressions of Section 3. Given a distribution of values for the exogenous variables, one can compute the expected values for the endogenous variables: First, the coefficients in Table 4 allow computation of the expected pretest score; next the coefficients in Table 5, with the computed pretest value, allow computation of the expected attendance rate; and so forth.

Table 10 shows the results of computing the values of the endogenous variables under the alternative assumptions that the system uses and does not use radio. Note that the within-year dropout probability is slightly *higher* for the radio students, but that their end-of-year failure probability is much lower, almost entirely because of radio's effect on the posttest score and the subsequent effect of the posttest score on failure probability. Notice, too, that Table 3 indicates that the mean failure rate in the radio group is slightly higher than for the nonradio group; this well illustrates the importance of disentangling the multiple determinants of failure through statistical analysis. Though the radio group differed only moderately from the nonradio group in terms of mean values for most variables, the differences all favored the nonradio group in terms of factors determining failure propensity. A much higher fraction of the radio group came from agricultural families, leading to lower posttest scores and, thereby,

TABLE 10

Effect of Radio on
the Endogenous Variables

| Variable | Estimated expected value | |
|---|---|---|
| | Without radio | With radio |
| **PRE** | 20.0 | 20.0 |
| **ATTAV** | 12.5 | 12.5 |
| **DROP** | .013 | .025 |
| **POST** | 47.8 | 58.0 |
| **FAIL** | .45 | .33 |
| **RENRL** | .91 | .92 |

*Note.* This table shows the estimated expected values of the endogenous variables in the system under the assumption that the vector of exogenous variables (except radio) is distributed in the population in the same way that it is distributed in the subsample of our sample for which we have complete information on the exogenous variables. (Because of the nonlinearity of the logit transformation, the expected values of the vector of endogenous variables is *not*, of course, the estimated function of the expected value of the exogenous variables.) The radio variable takes on the value of either 1 ("With radio" column) or 0 ("Without radio" column). All values are reported to three significant digits.

higher failure probabilities. The radio group also had fewer repeaters and fewer males, and both factors caused it to have more failures. These factors are all systematically accounted for in the failure comparison of Table 10, and we use those values in the cost-effectiveness comparison.

It would be inappropriate, however, to take the values of the variable **FAIL** in Table 10 for the values of $f$ to be used in computing cost per graduate. We need also to consider the (small) effect of within-year dropouts. For the nonradio group, 5% of the students are predicted to drop out and 36% of those remaining fail; thus

$$f = 1 - (1 - .03)(1 - .45) = .457.$$

For the radio group we have

$$f = 1 - (1 - .025)(1 - .33) = .347.$$

**Cost-effectiveness analysis.** We are now in a position to calculate the cost per first-grade graduate for both the radio groups and the nonradio groups. Using the simple formula at the beginning of this section we can compute that, for the nonradio group, the cost per graduate is given by

$$C_g = \$54/(1-.457) = \$99.45 .$$

For the radio group:

$$C_g = \$57/(1-.347) = \$87.29 .$$

Even though introducing radio raises the cost per student, $C_s$, by \$3.00 per year, it reduces the cost per graduate by \$12.16 or about 12%. Another way of putting this is that, for a given total level of expenditure on first-grade education, about 12% more children would graduate from first grade each year with the project in operation than without it.[9]

These methods of computing cost-effectiveness can easily be extended to cycles covering more than one grade (Jamison & Leslie,

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[9] An alternative way of thinking about the cost-effectiveness of the project is to view as wasted the resources spent on a student if he fails first grade. While this method would give some insight into the nature of the advantage of the project over traditional instruction, the method of calculating cost-effectiveness described in the text is preferable. The reason is that production of graduates is a more appropriate criterion of effectiveness than is avoidance of wastage.

1977, pp. 114–150; Lethem, 1977, chap. 13): When the data become available from Nicaragua concerning the project's impact at the second- and third-grade levels, this will be done.

## 5. CONCLUSIONS

This analysis of data concerning 1975 first-grade students in Nicaragua leads to four principal conclusions:

1. The Nicaragua Radio Mathematics Project can, as previous evaluations have already shown, significantly improve the mathematics performance of first-grade students. Students exposed to the radio lessons scored about three-fourths of a standard deviation higher on standardized tests than did control students.
2. In large part because of their improved mathematics competence, students exposed to radio lessons were considerably less likely to fail first grade than were controls. The estimated probability of failure of students exposed to radio was .33; the estimated probability for control students was .45.
3. Introducing project radio lessons would add about $3.00 to the present cost of $54.00 per student per year of elementary education in Nicaragua. However, principally because of the impact project lessons have in reducing repetition rates, the cost per first-grade *graduate* with project lessons would be about $12.16 less than the $99.50 it would be without them.
4. Through its effect on achievement both directly and indirectly through the effect of achievement on failure propensity, introduction of radio (slightly) decreases between-year dropout propensity, a finding at the micro-level consistent with that of Levy (1971) at a cross-national level.

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## *Chapter 8*

# PATTERNS OF PROMOTION AND WASTAGE FOR NICARAGUAN FIRST-GRADE STUDENTS

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THIS CHAPTER is concerned with problems often referred to as wastage—student dropout and repetition. Data from Nicaragua allow us to follow the progress of first-grade students from the beginning of one school year to the beginning of the next. We compare those who advance to second grade, those who repeat first grade, and those who do not return to school, as a first step in formulating hypotheses about the causes of student dropout and repetition.

Jamison (in chap. 7 of this volume) has reviewed the literature on determinants of student failure and repetition and finds relatively few studies directed toward these issues. He concludes from this survey that

> given a school system's promotion policy, a child's performance and attendance at school. . . play important roles; this literature is more suggestive than definitive, more qualitative than quantitative. (p. 200)

Jamison, in his analysis of student achievement and background data from Nicaragua (chap. 7), suggests that the radio mathematics instructional program can have an impact on the repetition problem in Nicaragua through its effect on student achievement. This chapter presents a complementary set of analyses that provide a preliminary quantitative description of patterns of progression through the grades and that explore dimensions of the repetition and dropout problems other than those investigated by Jamison. We use a discrete classification of student outcomes and examine simple relationships among these outcomes, student characteristics, and performance levels.

The first section of the chapter describes the Nicaraguan setting of the project and the types of data that were collected; it also describes in some detail the schools and teachers that formed the sample. In the second section we discuss patterns of progression from one grade to the next and illustrate them with data for 1974 describing first-grade students. Several variables related to student flow are examined in detail in order to deepen our understanding of the student characteristics that are related to the three flow outcomes: normal progress, repetition, and dropping out. In the third section we examine briefly a set of data collected in 1975, which includes students who used the radio instructional program. Finally, the last section summarizes the results and indicates directions for further work.

## 1. DESCRIPTION OF THE NICARAGUAN SETTING AND THE DATA BASE

In this section we present very briefly some relevant features of the Nicaraguan educational system. We then describe the general characteristics of the schools and teachers that comprise the present sample.

### *The Nicaraguan Setting*

The Nicaraguan school year begins in mid-February and ends in mid-November. There are about 180 days in the school year, which is divided into two semesters separated by a midyear vacation in July.

Primary education begins with Grade 1 and ends with Grade 6. There are no public kindergartens and the official age for entering first grade is seven years. Matriculation is on a first-come, first-served basis and most schools will accept children until a class size of 60 has been reached. Such large classes are usually found only at the first-grade level; as we note below, enrollment at higher grade levels is much lower.

Primary education in Nicaragua is tuition free and compulsory. However, only about two-thirds of the school-age children are in school. Basic data for the primary-school system, obtained from the Ministry of Public Education, are presented in Table 1. About half the children who enter urban schools eventually complete sixth grade; the comparable figure for rural schools is 5%. On the average, it takes about 40 pupil-years to produce a sixth-grade graduate in the rural schools. In rural areas, about 50% of the children in school are in the first grade; even in urban schools more than one-fourth of the children are in first grade.

There is no nationwide examination system; promotion from one grade to the next, although guided by regulations promulgated by the

TABLE 1

Basic Data for Nicaraguan Primary Schools in 1974

| Variable | Urban | Rural | Total |
|---|---|---|---|
| Number of schools | 695 | 1,579 | 2,274 |
| Number of classrooms | 4,172 | 2,246 | 6,418 |
| Total enrollment | 219,095 | 114,568 | 333,663 |
| Enrollment in Grade 1 | 60,806 | 62,251 | 123,057 |
| Proportion of total school enrollment in Grade 1 | .28 | .54 | .37 |
| Proportion of enrollment in Grade 1 promoted to Grade 2 | .57 | .33 | .49 |
| Repetition rate—Grade 1 | .20 | .18 | .19 |
| Dropout rate—between Grade 1 and Grade 2 | .23 | .49 | .32 |
| Fourth-grade completions per 1,000 entrants | 527 | 82 | 305 |
| Sixth-grade completions per 1,000 entrants | 440 | 53 | 257 |
| Number of pupil-years to produce a sixth-grade graduate | 10.45 | 40.67 | 26.89 |

Ministry of Education, is ultimately the decision of the classroom teacher. According to the Ministry rules, a child must have been present at least two-thirds of the school year in order to be eligible for promotion. For students who meet the attendance requirement, the teacher is instructed to base his pass-fail decision on both class work and performance on final examinations. The child is graded on seven subjects. If he fails two or more subjects, the child must repeat the grade. If he fails only one subject, he may take a retest before the beginning of the next school year and a passing grade allows him to enroll in the next higher grade.

### *Selection of the Samples*

The sets of data described here were collected for first-grade students in two different calendar years and under somewhat different conditions. The 1974 data were gathered for students in 30 randomly selected classrooms. None of these students had experience with radio instruction, and the information collected was used as a baseline for planning purposes. The 1975 data were collected for

16 classes, selected nonrandomly, that used radio lessons and for 9 randomly selected classes that did not use the radio lessons and served as a control group.

**The 1974 sample.** The classes constituting the 1974 sample were selected from primary schools, stratified by school location, in the Department of Masaya. There are approximately 100 primary schools in the department, with about 170 first-grade classes. The Ministry of Education characterizes schools as urban if they are located within the boundaries of a municipality, otherwise as rural. In the years under consideration, the project subdivided the urban classification, calling *urban* only the schools in the two large towns, Masaya and Masatepe. Schools in other municipalities were called *municipal*. The reasons for this decision are discussed in Searle, Friend, and Suppes (1975): We thought there might be important differences between schools in large and small towns. Although this distinction was subsequently abandoned, we retain it in this presentation because the school population was stratified along this dimension before random selection of classrooms was made.

A classroom was considered eligible for selection if there were 15 or more first-grade children matriculated. From each stratum (rural, municipal, and urban) 10 classes were chosen at random from the list of eligible classes. The procedure sampled 10 rural schools, 10 urban schools, and 5 municipal schools. (There were very few municipal schools—hence the smaller number in the sample.)

**The 1975 sample.** The 16 radio classes were chosen to provide a representative sample of classes (see Searle et al., 1975); the 9 control classes were selected from the schools that had been used in the 1974 sample. The distribution of these classes by school location is shown in Table 2. The sample included classes from 6 municipal schools, 8 rural schools, and 10 urban schools.

TABLE 2

Distribution of Classes in 1975 Sample by School Location

| Location | Number of classes | |
|---|---|---|
| | Radio | Control |
| Rural | 5 | 2 |
| Municipal | 4 | 3 |
| Urban | 7 | 4 |
| TOTAL | 16 | 9 |

TABLE 3

Characteristics of Schools in 1974 and 1975 Samples

| Characteristics | Minimum | Maximum | Mean |
|---|---|---|---|
| 1974<br>($N$ = 25) | | | |
| Sessions per day | 1 | 2 | 1.5 |
| Rooms | 2 | 12 | 5.5 |
| Teachers | 1 | 24 | 9.2 |
| Girls in school | 36 | 470 | 162.8 |
| Boys in school | 40 | 463 | 162.6 |
| First-grade classes | 1 | 7 | 2.6 |
| Girls in first grade | 11 | 158 | 55.8 |
| Boys in first grade | 19 | 170 | 57.8 |
| 1975<br>($N$ = 24) | | | |
| Sessions per day | 1 | 2 | 1.0 |
| Rooms | 2 | 10 | 6.0 |
| Teachers | 2 | 20 | 9.1 |
| Girls in school | 30 | 398 | 164.9 |
| Boys in school | 39 | 404 | 162.4 |
| First-grade classes | 1 | 7 | 2.8 |
| Girls in first grade | 11 | 164 | 58.6 |
| Boys in first grade | 16 | 144 | 65.1 |

### *School Variables*

Table 3 summarizes the information collected about the schools sampled in both years. Most of the schools were small; however, the largest had 12 rooms, operated on double session, and had 933 students in 24 classes, an average matriculation of just under 40 students per class.

Because the 1974 schools were randomly selected they are more representative of the population; we therefore restrict further description to those schools. Table 4 compares the schools in urban, municipal, and rural locations along several dimensions. The municipal and urban schools are very similar; the rural schools, however,

TABLE 4

Comparison of Rural, Municipal, and Urban Schools: 1974

| Characteristic | Rural (*N* = 10) | Municipal (*N* = 5) | Urban (*N* = 10) |
|---|---|---|---|
| Number of schools with two sessions per day | 1 | 3 | 9 |
| Mean number of rooms | 3.50 | 7.40 | 6.60 |
| Mean number of teachers | 4.10 | 12.20 | 12.80 |
| Mean number of first-grade classes | 1.50 | 3.20 | 3.40 |
| Mean number of students | 150 | 433 | 447 |
| Proportion of students in first grade | .42 | .30 | .35 |

have about half as many rooms, about one-third as many teachers, and about one-third as many students as the urban and municipal schools. The proportion of students in first grade, although highest for rural schools, is in all cases well above .167, which would obtain if a student body of unchanging size moved through six grades.

### *Teacher Variables*

Teachers in the primary schools in Nicaragua acquire status and salary levels on the basis of their educational background. Those who are fully qualified, as are the majority of Nicaragua's teachers, receive the title of *Maestro de Educación Primaria* or Primary School Teacher, which is awarded to those who successfully complete a six-year program at a normal school after graduation from sixth grade.

Many teachers, however, are not fully certified, and there are several categories based on different types of schooling. The highest category short of full certification is *Maestro de Educación Básica* or Teacher of Basic Education. A teacher receives this title after completing the first three years, or "basic cycle," of the normal-school program. A lower category, *Certificado de Aptitud* or Certificate of Aptitude, is awarded to those who have had schooling at the secondary level in a field other than education and have completed five years of teaching. The lowest category, *Empíricos*, is for teachers who have not had any schooling beyond the primary level.

Many of the older teachers are fully certified without having completed six years of normal school because earlier programs required either four or five years instead of six. From 1938 to 1948 only four years of normal school were required for full certification. In 1948 the program was increased to five years, and in 1954 to six years. Two years later the program was reduced to five years; in 1969 the six-year program was reinstated.

Against this background we examine the teachers who comprised the 1974 and 1975 samples. The two groups are compared in Tables 5 and 6. The teachers in the 1975 sample were slightly younger and less experienced than those in the 1974 sample, but the educational backgrounds of the two groups were very similar. For about three-quarters of the teachers, the highest level of training was a normal-school degree; of the remainder, a few had some university training, a few had a regular secondary degree, and the rest had less than a secondary degree. The teachers were predominantly female. Their reported ages ranged from 19 to 50 years and the most experienced reported up to 31 years of teaching.

As in the discussion of schools, the more detailed examination is restricted to the randomly selected 1974 sample. Table 7 displays the relationship between age and years of education for the 24 teachers for which both figures were recorded. As one might expect, the younger teachers tend to have more education.

Teachers from different school locations are compared in Table 8. The teachers in urban schools are slightly younger and less experienced than those in the rural and municipal schools; there was no difference in education level among the groups. The teachers from urban schools were in general a more homogeneous group; all 10 had normal-school degrees (and no higher training) and all were women. (The few men in the sample all taught in rural schools.) Among the teachers in the other groups (municipal and rural) were two with

TABLE 5

Composition of 1974 and 1975 Teacher Samples

| Teacher variables | 1974 | 1975 |
|---|---|---|
| Number of teachers | 30 | 25 |
| Number of male teachers | 3 | 2 |
| Percentage with some university training | 7 | 16 |
| Percentage with normal school degree | 77 | 76 |

TABLE 6

Comparison of 1974 and 1975 Teacher Samples: Age, Education, and Teaching Experience

| Teacher variables | Minimum | Maximum | Mean |
|---|---|---|---|
| | 1974 | | |
| Age | 20 | 49 | 34.4 |
| Years of education | 8 | 14 | 11.2 |
| Years of teaching experience | 1 | 30 | 13.4 |
| | 1975 | | |
| Age | 19 | 50 | 31.3 |
| Years of education | 7 | 14 | 11.2 |
| Years of teaching experience | 0 | 31 | 11.0 |

some university training, one with both a normal-school and a secondary-school degree, and two who had completed only the first few years at the secondary level.

In summary, the teachers in the sample are almost all women, they have had 11 or 12 years of schooling, their mean age is in the mid-30s and they have had, on the average, about 12 years of teaching experience. The teachers in rural schools are somewhat older and more experienced but slightly less well educated than those in urban schools, and in general they are a more heterogeneous group with respect to their educational background.

TABLE 7

Relation Between Teacher Age and Education: 1974

| Years of education | Age | | |
|---|---|---|---|
| | Under 29 | 29 to 40 | Over 40 |
| Less than 11 | 0 | 2 | 2 |
| 11 | 3 | 4 | 3 |
| 12 | 5 | 2 | 2 |
| More than 12 | 0 | 0 | 1 |

*Note.* Age and education data were provided for only 24 teachers.

TABLE 8

Comparison of Rural, Municipal, and Urban Teachers: 1974

| Characteristic | Rural (*N* = 10) | Municipal (*N* = 10) | Urban (*N* = 10) |
|---|---|---|---|
| Mean age | 37.7 | 35.8 | 29.5 |
| Mean years of experience | 15.1 | 14.8 | 9.9 |
| Mean years of education | 11.6 | 10.6 | 11.4 |

### *Student Variables*

The student variables used in the analyses reported here are listed and described in Table 9. Except for scores on the project-administered achievement test, information about students was obtained from two special forms designed by the project and filled out by teachers. The first form was distributed at the end of the school year, the second at the beginning of the following school year. The

TABLE 9

Definition of Variables Describing Students

| Label | Definition |
|---|---|
| **SEX** | 0 if female, 1 if male |
| **AGE** | Student age in years |
| **RMU** | Location of school student attends: rural, municipal, or urban |
| **DIST** | Number of meters student walks to school |
| **AGOCC** | 1 if parental occupation is agricultural, 0 otherwise |
| **REPT** | Number of years student previously in first grade |
| **DAYS** | Number of days attended during school year |
| **TOOK1** | 1 if student took teacher-prepared final examinations, 0 if not |
| **PASS1** | 1 if student passed teacher-prepared final examinations, 0 if failed |
| **PASSM** | 1 if student passed teacher-prepared mathematics final, 0 if failed |
| **POST** | Score on project posttest of mathematics achievement |
| **ENROL** | 1 if student reenrolled in school the following year, 0 if not |
| **GRADE** | Grade level at which student reenrolled |

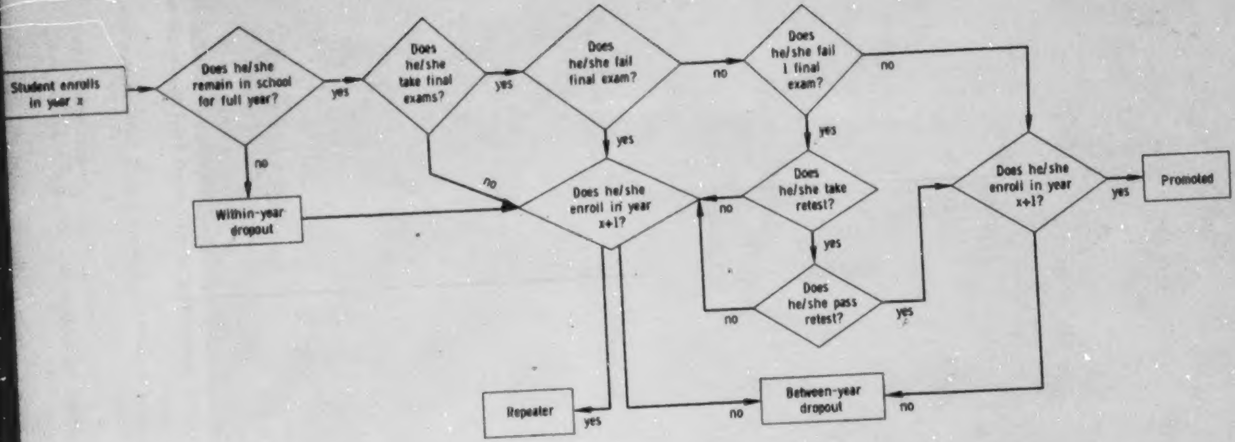
Student enrolls in year x
Does he/she remain in school for full year?
yes
no
Within-year dropout
Does he/she take final exams?
yes
no
Does he/she fail final exam?
yes
no
Does he/she fail 1 final exam?
no
yes
Does he/she enroll in year x+1?
Does he/she take retest?
no
yes
Does he/she pass retest?
no
yes
Does he/she enroll in year x+1?
yes
Promoted
no
Repeater
yes
no
Between-year dropout
no

FIGURE 1. Patterns of student flow for a single grade level.

second form asked the teachers to provide information about students who were no longer in their classes; not surprisingly, the incidence of missing data was higher for these variables.

Table 10 presents descriptive statistics for variables for the 1974 sample of students. The table also indicates the extent to which data are missing.

## 2. THE 1974 FIRST–GRADE STUDENT DATA

### *Patterns of Student Flow*

Patterns of flow for a single grade level are summarized in Figure 1. We can identify two major attendance patterns during the school year. Some children come to school for the entire year (i.e., show positive attendance for most months, including the last), while others, whom we identify as *within-year dropouts*, attend for a portion of the year and then show no further attendance. (We find relatively few children who miss one or more entire months and then return to school for the rest of the year.)

When we look at a child who enrolled in year $x$ we see three major outcomes in year $x + 1$: The child returns to school at the next grade level—*promotion*; the child does not return to school—*between-year dropout*; or the child returns to school at the same grade level—*repetition.*

There is one main route to promotion, as shown across the top of Figure 1: The student remains in school all year and takes and passes the final examinations. There are several routes to the other two

TABLE 10

Descriptive Statistics for Variables of 1974 Student Sample

| Variable | Number of observations | Range | Mean | *SD* |
|---|---|---|---|---|
| **SEX** | 1,191 | 0–1 | .562 | .496 |
| **AGE** | 1,190 | 5–17 | 8.737 | 1.755 |
| **DIST** | 1,059 | 10–8,000 | 606.900 | 658.200 |
| **AGOCC** | 1,138 | 0–1 | .224 | .417 |
| **REPT** | 1,191 | 0–3 | .492 | .737 |
| **DAYS** | 1,041 | 0–188 | 133.800 | 44.700 |
| **TOOK1** | 1,102 | 0–1 | .790 | .407 |
| **PASS1** | 1,111 | 0–1 | .606 | .489 |
| **PASSM** | 1,026 | 0–1 | .663 | .473 |
| **POST** | 761 | 12–63 | 36.880 | 11.083 |
| **ENROL** | 1,039 | 0–1 | .832 | .397 |
| **GRADE** | 919 | 1–2 | 1.615 | .487 |

outcomes. A repeater may have been a within-year dropout who returns or a student who failed the previous year. The between-year dropout may not have attended school for the entire previous year; if he did, he may or may not have passed the final examinations. Thus, neither the dropout nor the repeater is necessarily a weak student.

Table 11 presents the frequency with which different flow outcomes occur in the 1974 set of data. The classifications were derived using four variables, **TOOK1**, **PASS1**, **ENROL**, and **GRADE**. Values for some of these variables were missing for some students, but by considering the preponderance of the evidence it was possible to assign almost all students to a pattern.

Three types of students are identified as progressing to second grade, and together they constitute 47% of the original first-grade matriculation. The vast majority (485) passed the final examinations and were promoted. Eighty students are recorded as failing the final examinations. Five of them took and passed the retest; we do not know how the others qualified for second grade.

TABLE 11

Progression Patterns for First-grade Students: 1974

| Outcome[a] | N | % | N | % |
|---|---|---|---|---|
| Promotion | | | 565 | 47.4 |
| Passed finals, enrolled in Grade 2 | 485 | 40.7 | | |
| Failed finals, passed retest, enrolled in Grade 2 | 5 | .4 | | |
| Failed finals, no record of retest, enrolled in Grade 2 | 75 | 6.3 | | |
| Repetition | | | 354 | 29.8 |
| Failed finals, enrolled in Grade 1 | 156 | 13.1 | | |
| Passed finals, enrolled in Grade 1 | 65 | 5.5 | | |
| Did not take finals, enrolled in Grade 1 | 133 | 11.2 | | |
| Between-year dropout | | | 270 | 22.7 |
| Failed finals, did not enroll | 39 | 3.3 | | |
| Passed finals, did not enroll | 119 | 10.0 | | |
| Did not take finals, did not enroll | 112 | 9.4 | | |
| Unknown pattern | | | 2 | .2 |
| No record of finals, enrolled but grade unknown | 2 | .2 | | |
| TOTAL | 1,191 | | | |

[a] Performance on finals in 1974, enrollment in 1975

Of the remaining students, more than half are repeaters—about 30% of the entire sample. These students have three kinds of histories. Just under half the repeaters failed the final examinations in 1974 and reenrolled in first grade in 1975. Another substantial fraction did not take the finals. (Presumably many of these are within-year dropouts, as discussed below.) Finally, 5% of the students passed the finals and reenrolled, but in Grade 1, not Grade 2. (This outcome, which was unanticipated, is not shown in Figure 1.)

The remaining students are identified as between-year dropouts, which is the most equivocal classification because it includes some students for whom both final-examination and enrollment data were missing. Thus, the figure 22.7% represents a maximum estimate of the between-year dropout rate for this sample of students.

It seems reasonable to classify students who did not attend school during the last month and who did not take the final examinations as within-year dropouts. Adopting this criterion, Table 12 shows that 81% of the between-year dropouts had already dropped out before the end of the previous school year. The comparable figure for repeaters is 53%. That is, of the students who reenrolled in first grade in 1975, slightly more than half of them had been within-year dropouts in 1974.

Referring once again to Table 11, we notice several interesting points. The most striking is the small percentage of children who are promoted and reenroll—less than half. Also interesting are the records of students who repeat or drop out. Sixty-five students, or 18% of the repeaters, are recorded as having passed the final examinations. These students were presumably qualified to go on to second grade; we do not know why they returned to first grade. Of the dropouts who took the final examinations, only 25% failed them (39 of 158 students). Almost half the dropouts, had they returned to school, would have been qualified to enter second grade. It appears that many repeaters and dropouts are successful students, at least as measured by the major criterion used for deciding promotion—the final examinations.

We summarize these findings about patterns of flow in Figure 2—a simplified version of Figure 1—which shows the outcomes for 100 children. Of each 100 students who enrolled in first grade in 1974, 47 progressed to Grade 2, 30 reenrolled in Grade 1, and 23 did not return to school in 1975.

**Flow outcomes for subpopulations.** Two ways of stratifying the population are of interest in examining flow outcomes, namely, stratification by school location (rural, municipal, urban) and stratification by repetition record (those who are and those who are not in first grade for the first time).

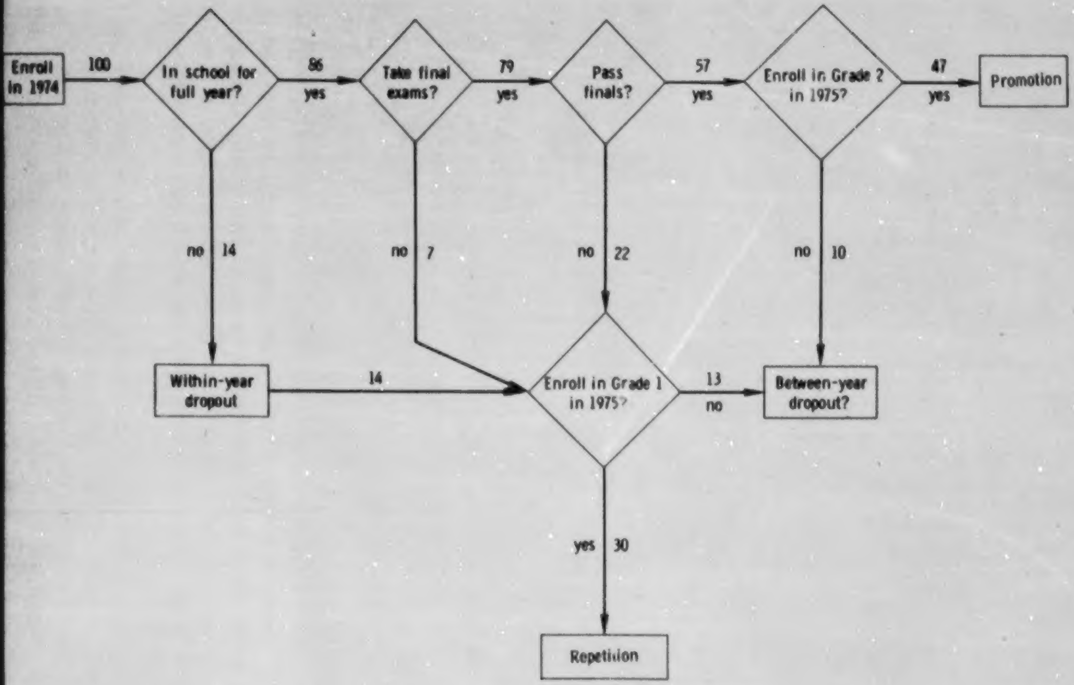
Enroll in 1974
100
In school for full year?
86
yes
Take final exams?
79
yes
Pass finals?
57
yes
Enroll in Grade 2 in 1975?
47
yes
Promotion
no 14
no 7
no 22
no 10
Within-year dropout
14
Enroll in Grade 1 in 1975?
13
no
Between-year dropout?
yes 30
Repetition

FIGURE 2. Outcomes for 100 first-grade matriculants.

TABLE 12

Attendance During Last Month of School for Students Who Did Not Take Finals: 1974

| Number of days attended in Month 10 | Repeater | | Between-year dropout | |
|---|---|---|---|---|
| | *N* | % | *N* | % |
| 0 | 71 | 53.3 | 91 | 81.2 |
| 1–5 | 13 | 9.8 | 3 | 2.7 |
| 6–10 | 39 | 29.3 | 10 | 8.9 |
| 11–16 | 10 | 7.5 | 8 | 7.1 |
| TOTAL | 133 | | 112 | |

Table 13 presents the flow outcomes for students from rural, municipal, and urban schools. The percentage of children promoted is about the same in all three types of schools, 45–49%. Comparing these figures with those presented in Table 1 for the entire country, we find that the rate of promotion for urban schools in our sample is lower and the rate for rural schools is higher. This may be because the schools in the department of Masaya are not typical of the country or it may be related to differences in methods of collecting the data.

Referring again to Table 13, we see that rural schools show the highest, and urban schools the lowest, repetition rates. The repetition rate reported for the nation's urban schools, .20 (see Table 1), is about the same as that for the sample's urban schools. The rate reported for the nation's rural schools is about half that observed in our sample—.18 as compared with .37. In our sample the rural schools show the lowest dropout[1] rate; the rate for the urban schools is almost 10% higher. This relationship is opposite that seen in the national data where the reported dropout rate for rural schools (.49) is about twice that for urban schools (.23).

Table 14 presents flow outcomes separately for first-grade students who are in school for the first time (nonrepeaters) and those who have been in first grade at least once before (repeaters). The repeaters, who comprise 35.5% of the sample, are more likely to be promoted, less likely to repeat, and less likely to drop out than the nonrepeaters. Thus, on the whole, the outlook for repeating first graders in our sample is more favorable than that for new students.

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[1] Unless noted, "dropout" in the subsequent discussion refers only to between-year dropouts.

TABLE 13

Flow Outcomes by School Location: 1974

| Outcome | Percentage of students | | |
|---|---|---|---|
| | Rural<br>(*N* = 406) | Municipal<br>(*N* = 392) | Urban<br>(*N* = 393) |
| Promotion | 44.6 | 48.7 | 49.2 |
| Repetition | 36.9 | 28.8 | 23.2 |
| Dropout | 18.2 | 22.2 | 27.5 |
| Unknown | .3 | .3 | .1 |

### *Relation Between Flow Outcomes and Student Variables*

In this section we will probe more deeply into the patterns of flow we have identified, asking how such variables as student age, school attendance, and achievement (as measured by a project mathematics test) are related to flow outcomes. We have chosen these variables because they are all strongly related to flow. At the end of the section we examine several other variables that are of interest but seem less striking in their effects.

In order to simplify the analysis we have collapsed the variables with many values; the resulting redefinitions are shown in Table 15. The attendance variable, **ATT**, the achievement variable, **ACH**, and the age variable, **SAGE**, have three values, while the repetition variable, **AGAIN**, has two. For each variable we examine two sets of subpopulations: repeaters and nonrepeaters, urban and rural students. In the latter comparison we ignore the municipal students, who are in some respects like the rural students and in some like the urban students. (It is not appropriate to group them with the urban students

TABLE 14

Flow Outcomes by Repetition History: 1974

| Outcome | Percentage of students | |
|---|---|---|
| | Nonrepeater<br>(*N* = 768) | Repeater<br>(*N* = 423) |
| Promotion | 42.4 | 56.5 |
| Repetition | 31.6 | 26.2 |
| Dropout | 25.7 | 17.3 |
| Unknown | .3 | 0 |

TABLE 15

New Variables Obtained from Many-valued Variables: 1974

| Variable | Definition | Number of students | Percentage |
|---|---|---|---|
| **SAGE** | 1 if **AGE** < 8 | 297 | 25.0 |
| | 2 if **AGE** = 8 | 362 | 30.4 |
| | 3 if **AGE** > 8 | 531 | 44.6 |
| **ACH** | 1 if **POST** < 32 | 251 | 33.0 |
| | 2 if **POST** between 32 and 42 | 234 | 30.7 |
| | 3 if **POST** > 42 | 276 | 36.3 |
| **ATT** | 1 if **DAYS** < 130 | 347 | 33.3 |
| | 2 if **DAYS** between 130 and 160 | 325 | 31.2 |
| | 3 if **DAYS** > 160 | 369 | 35.5 |
| **AGAIN** | 0 if **REPT** = 0 | 768 | 64.5 |
| | 1 if **REPT** > 0 | 423 | 35.5 |

because a sampling procedure stratified only by urban and rural location would have fewer than one-third municipal students.)

**Relation between flow and age.** Students in the first-grade sample ranged in age from 6 to 15 years. Although the official age for entrance into school is 7 years, the modal age in our sample is 8 years. As noted in Table 15, only one-fourth of the children are under 8 years of age, while 45% are older than 8.

The relation between flow outcomes and age for the entire sample is presented in Figure 3a. The percentage of children promoted increases with age, and the percentage who repeat decreases. The percentage of each age group that drops out remains roughly the same, varying from 19% to 25%. Of the youngest group, approximately 30% are promoted, 25% drop out, and about 45% repeat the grade. For the oldest group the percentage promoted almost doubles, to 55%, while the percentage repeating is about halved.

Figures 3b and 3c present the same information separately for repeaters and nonrepeaters. For every age group a higher percentage of repeaters than nonrepeaters is promoted (see also Table 14). For nonrepeaters, repetition is strongly related to age; the younger students are more likely to repeat. (Recall that "nonrepeaters" are those

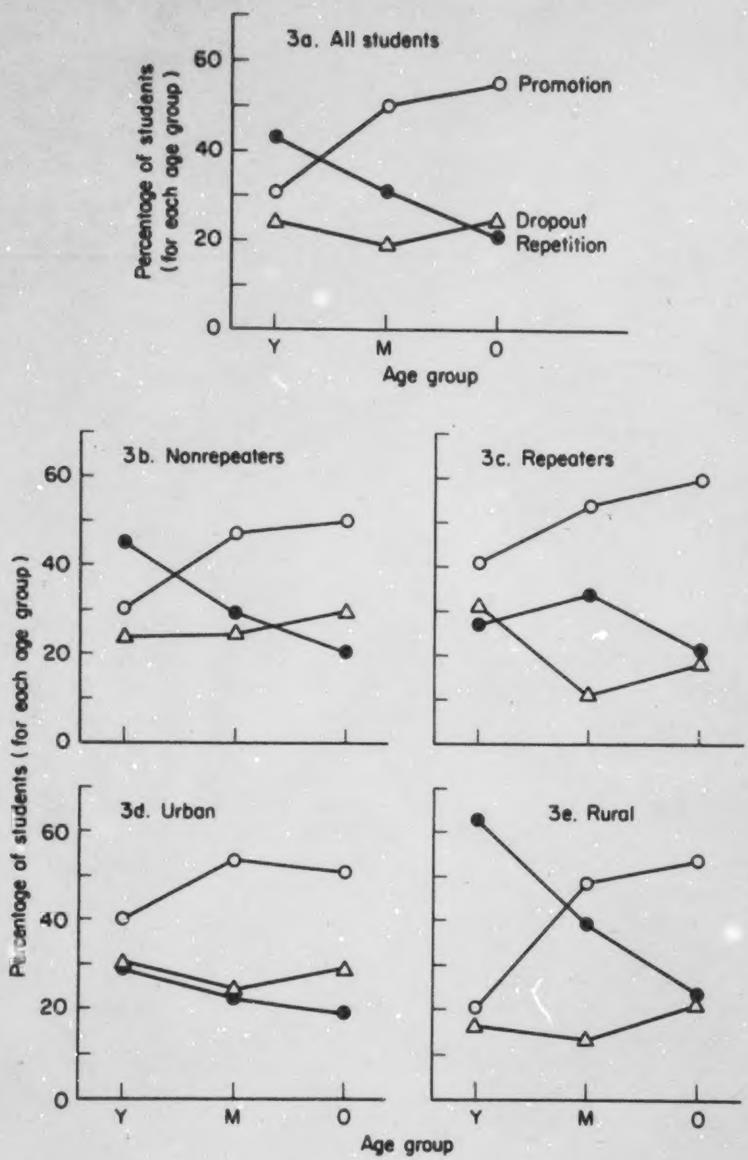

FIGURE 3. Relation between flow outcomes and age for several populations, 1974 sample.

who are in first grade for the first time in 1974; the outcome "repetition" refers to reenrolling in first grade in 1975.) Perhaps not surprisingly, the relationship between age and repetition is more complex for repeaters—students who are already repeating first grade. The 8-year-old group has a higher percentage of repeaters than the younger or older groups. (The number of students who repeat at least twice is not small; the 1974 repeaters who repeat in 1975 comprise 11% of the sample.)

We also observe in Figure 3c that the percentage of dropouts is lowest for 8-year-old repeaters. Thus, it seems that students who are at the modal age for the grade and who have been in first grade before have a high probability of returning to school, either to first or to second grade; very few of them drop out.

Figures 3d and 3e contrast rural and urban students. Age has relatively little effect on any of the outcomes for urban students. For rural students, age is only slightly related to rural dropouts but is strongly related to the other two outcomes. For the youngest group in rural schools, a very small percentage of students (20%) is promoted while more than 60% repeat.

The contrast in the relationship between age and promotion in rural and urban schools is highlighted in Figure 4, which shows the promotion rates for a selected group of students: those whose attendance is in the middle or high group and whose achievement is at the middle or high level. (This group is chosen to represent those able to meet the Ministry qualifications for promotion.) As is evident in Figure 4, age has little effect on the likelihood that urban students will be promoted, while for rural students the older students are almost twice as likely to be promoted as the younger ones.

We summarize the effect of age on the three flow outcomes as follows.

| | |
|---|---|
| Promotion: | Promotion is positively related to age for all subpopulations; viz., older students are more likely to be promoted than younger ones. (The effect is weakest for urban students.) |
| Repetition: | Repetition is strongly related to age for two subpopulati[illegible] nonrepeaters and rural students, and weakly re[illegible]or urban students; viz., younger students are more [illegible]y to repeat. The more complex relation for repeaters is described above. |
| Dropping Out: | Dropping out is essentially unrelated to age for all subpopulations except repeaters. For that group the percentage of dropouts in the 8-year-old group is quite low. |

**Relation between flow and attendance.** As can be seen in Table 15, the attendance variable **DAYS** was partitioned into three roughly

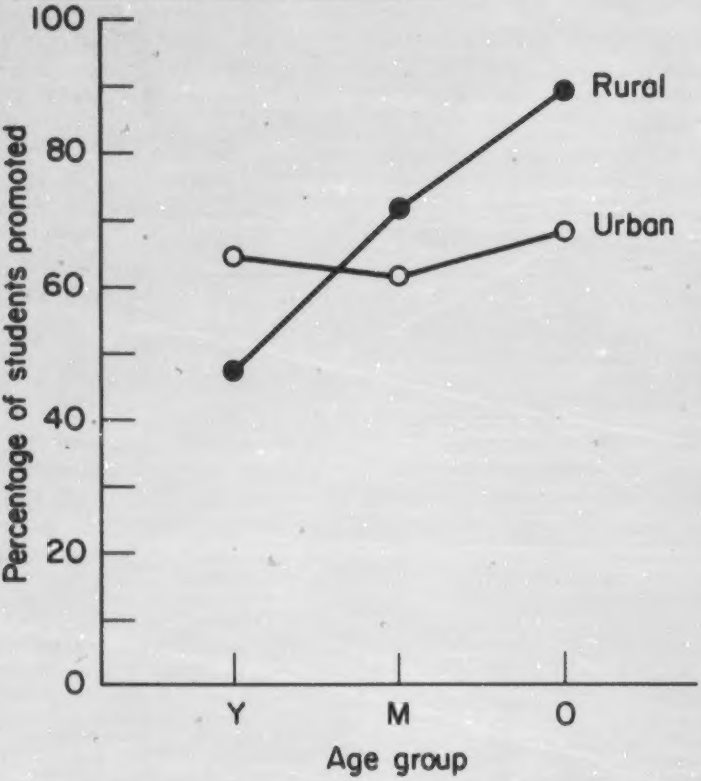

FIGURE 4. Relation of promotion to age for better-qualified students, 1974 sample.

equal groups. The top attendance group was present at least 160 days, or more than 85% of the school year. The middle group attended between 69% and 85% of the school year—on the average, about three-fourths of the time. The low group attended less than three-fourths of the time. According to the Ministry of Public Education guidelines for promotion, students in the low attendance group should not be promoted.

Figure 5a presents the relation between flow outcomes and attendance for the entire population. About 25% of the low attendance group (theoretically ineligible) was promoted. The percentage promoted is the same for the middle and high attendance groups, indicating that beyond a certain level (for the sample as a whole), improved

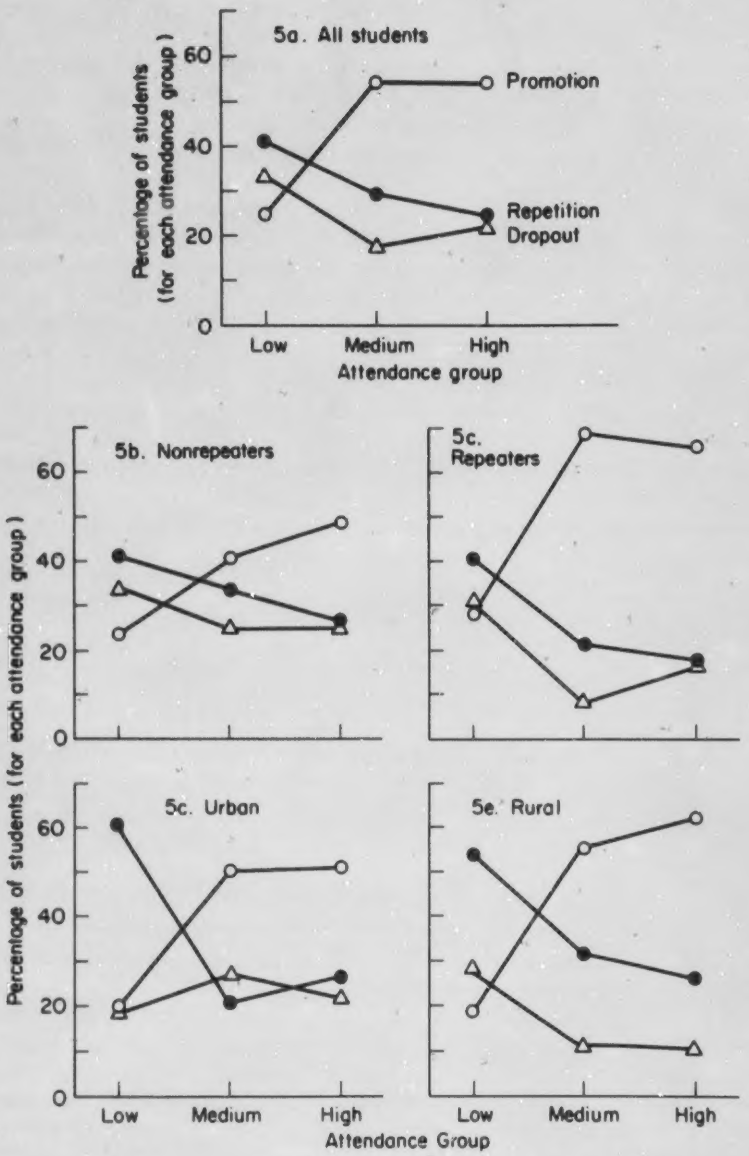

FIGURE 5. Relation between flow outcomes and attendance for several populations, 1974 sample.

attendance does not increase chances for promotion. As expected, pupils in the low attendance group are more likely to repeat or drop out than those in the middle or high attendance groups.

Figures 5b and 5c compare nonrepeaters and repeaters. Repeaters who meet the minimum attendance requirement have a promotion rate of almost 70%, the highest for any subpopulation in our data. For nonrepeaters in the medium and high attendance groups, promotion seems to be more sensitive to attendance; those in the highest attendance group have almost a 10% better chance of being promoted than those in the middle attendance group.

Figures 5d and 5e compare the rural and urban subpopulations. For both groups, approximately the same proportion of low attenders is promoted—20%. In urban schools the remaining low attenders are much more likely to drop out than to repeat; just the opposite is true in the rural schools, where 55% of the low attenders return to first grade the next year.

We summarize the effect of level of attendance on the three flow outcomes as follows.

| | |
|---|---|
| Promotion: | Despite the Ministry regulations, low attendance does not make promotion impossible. For all subpopulations about 25% of the low attenders are promoted. For all subpopulations promotion rates are much higher for middle and high attenders but are otherwise only weakly, if at all, related to attendance. |
| Repetition: | For all but urban students, the repetition rate falls as attendance increases. For urban students, repetition is essentially unrelated to attendance. |
| Dropping Out: | For all subpopulations the dropout rate is highest for low attenders—lower, but not much different, for the other two attendance groups. |

**Relation between flow and student achievement.** We have available to us only one measure of student achievement independent of the final examinations, the score on the project mathematics posttest, which must therefore serve as a proxy for a more global measure. At the higher end of the scale, the posttest score is strongly related to passing: Of the high-scoring group, 93% passed the final examinations and 97% passed the mathematics examination. At the other end of the scale, the relationship is not strong: 46% of the poor scorers passed the final examinations and 55% of them passed mathematics. However, as our discussion indicates, factors other than achievement seem to play a role in pass-fail decisions.

It is important in interpreting the results to recall that, unlike the other variables, which were reported by the teacher, the posttest score was obtained only from those students who happened to be in school on the day of testing. Thus, all the students who had already dropped out of school were not tested and those with poorer attendance records were more likely to miss the test than those who attended regularly.

Achievement on the mathematics test is related to promotion and repetition in the expected way, as shown in Figure 6a. The probability of being promoted increases sharply and the probability of repeating decreases sharply as achievement increases. The dropout rate, however, is essentially unrelated to achievement. It is important to recall that this group of dropouts, since they were present for the posttest, includes only students who remained in school for all of 1974 but did not return in 1975. For this group of students, failure to return to school is not influenced by their level of achievement.

With this data base it is not possible to examine the relation between achievement or ability level and within-year dropping out. We do this in Section 3, based on the 1975 set of data, which includes pretest scores.

As shown in Figures 6b to 6e, patterns for promotion and repetition are roughly the same for all subpopulations but in some cases the proportions of students differ. For each achievement level, about the same proportion of nonrepeaters and repeaters reenroll in first grade, but more repeaters are promoted. For each achievement level, more urban students are promoted and fewer repeat, as compared with rural students. Figures 6d and 6e illustrate the greater propensity of rural teachers to fail students as compared with urban teachers. For example, for the middle-scoring group, in urban schools 59% were promoted and 22% repeated first grade, as compared with 49% and 39%, respectively, for rural schools. Are the performance criteria for promotion being applied more stringently for first grade classes in the rural areas? To the extent that the project mathematics test is an adequate reflection of student achievement, our results suggest that this is the case.

Looking at the curves for dropping out in Figures 6d and 6e, we see a small difference for urban and rural students—a tendency for dropping out to decrease with increasing achievement for urban students and to remain constant or increase slightly with increasing achievement for rural students. That is, rural students in the high-scoring group may be slightly more likely to drop out than their compatriots in the middle- and low-scoring groups. If this finding holds up in future analyses, it may reflect the greater usefulness of the better students at home, and thus a tendency for their parents to be more likely to take them out of school.

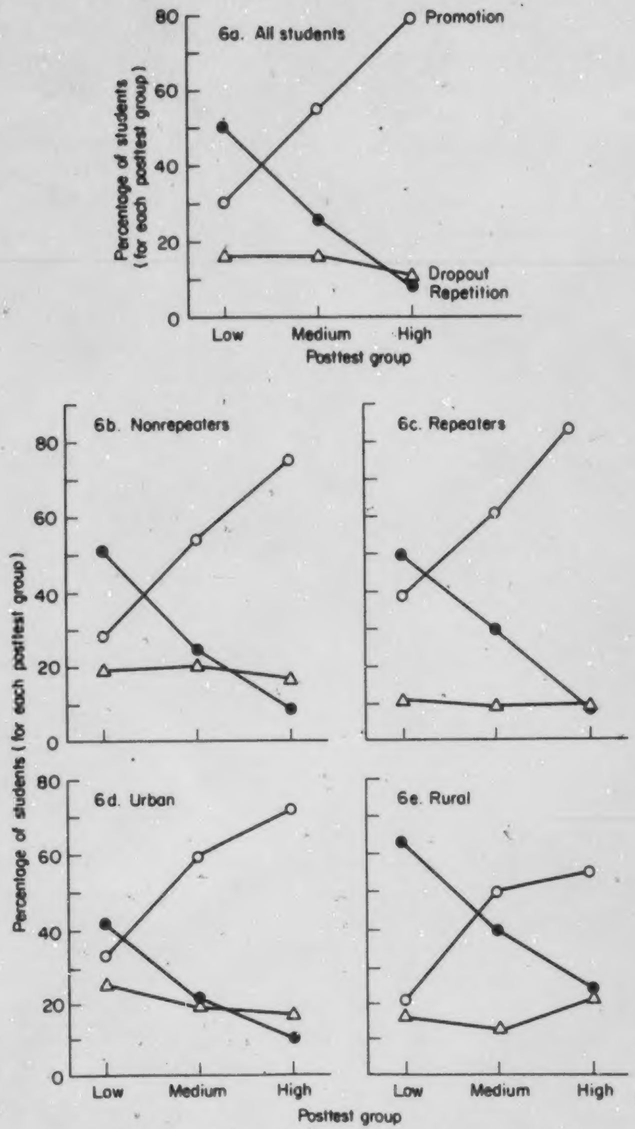

FIGURE 6. Relation between flow outcomes and posttest score for several populations, 1974 sample.

We now summarize the relation between student achievement and the three flow outcomes.

Promotion: Promotion is strongly related to achievement level for all subpopulations. However, at comparable achievement levels, rural students are less likely to be promoted than are urban students.

Repetition: Repetition is strongly related (inversely) to achievement level for all subpopulations. However, at comparable achievement levels, rural students are more likely to repeat than are urban students.

Dropping Out: For students who remain in school the entire year but do not return the next year, dropping out is essentially unrelated to achievement.

**Relation between flow and other student variables.** There are only a few student variables that have not yet entered into the discussion (see Table 10). We will examine three: **SEX**, **AGOCC**, and **DIST**. There is no relation between sex and flow: Almost exactly the same percentages of boys and girls are promoted (48%, 47%), repeat (29%, 30%), and drop out (22%, 23%). However, there are more boys in school—they constitute 56% of the sample.

Approximately one-third of the rural students are recorded as coming from farm families.[2] Table 16 compares flow outcomes for rural students from farm and nonfarm families. Outcomes for students from urban nonfarm families are included for comparison. The children from farm families are slightly more likely to be promoted and slightly less likely to repeat than the remainder of the rural children. The probability of dropping out is about the same. The urban students are more likely to be promoted, less likely to repeat, and more likely to drop out than either rural group.

Distance from school is not significantly related to flow outcome. The mean distance between home and school, in meters, is 626, 587, and 595 for promotion, repetition, and dropout groups, respectively.

### *Relationships Among Student Variables*

We turn now to an examination of the relationships among the student variables we have been considering, in particular, age, sex, farm children, distance walked to school, attendance, and achievement.

**Sex.** The student sample has more boys (56%) than girls, and this difference is greater for the urban population, which is 63% male. Students in municipal schools are about equally divided, while the

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[2] This proportion seems low, but we have no explanation for why it should be so.

TABLE 16

Flow Outcomes for Students
from Farm Families: 1974

| Outcome | Percentage of students | | |
|---|---|---|---|
| | Rural farm | Rural nonfarm | Urban nonfarm |
| Promotion | 40.8 | 37.2 | 48.8 |
| Repetition | 35.4 | 42.9 | 22.2 |
| Dropout | 18.9 | 19.9 | 28.7 |

rural population has the same percentage of boys as the entire sample—56%. The subpopulation consisting of farm children is also more heavily male (64%) than is the sample as a whole. Thus, it appears that most families send more boys than girls to school, but the difference is greatest for urban families and farm families.

Sex is unrelated to any of the other variables measured—student age, days attended, distance walked to school, or achievement as measured by the posttest. (We saw above that the students' sex is not related to flow.) The finding of no difference on the mathematics achievement test is contrary to the usual experience in the United States; it will be interesting to see if this finding is maintained in the higher grades.

**School location.** Children from the three school locations differ in all of the characteristics we have measured. As shown in Table 17, rural students are older, attend school less often, walk farther to

TABLE 17

Comparison of Students from
Different School Locations: 1974

| Variable | Rural | Municipal | Urban | F |
|---|---|---|---|---|
| Mean age in years | 8.9 | 8.8 | 8.4 | 19.1** |
| Mean number of days attended | 122.4 | 136.9 | 142.3 | 12.8** |
| Mean distance walked to school in meters | 757.7 | 561.7 | 516.4 | 12.9** |
| Mean posttest score | 35.1 | 36.9 | 38.3 | 5.1* |

* $p < .05$
** $p < .01$

school, and do less well on the mathematics posttest than do municipal or urban students. All the comparisons are statistically significant.

**Farm children.** Table 18 presents a comparison of rural children from farm and nonfarm families. None of the reported differences is statistically significant. As noted in the previous section, there are differences in flow outcomes for the two groups: Farm children have slightly more promising outcomes as compared with rural nonfarm children.

**Distance walked to school.** Rural students walk farther to school, on the average, than urban students. However, distance is uncorrelated with attendance ($r = -.04$), student age ($r = .07$), or performance on the posttest ($r = -.02$). Thus, although distance from school may help determine who decides to attend school, for this population it is not related to any of the outcomes of interest.

### *Regression Analysis of Determinants of Passing*

We have seen in the earlier discussion that age, repetition history, posttest score, and school location are all strongly associated with patterns of flow. Furthemore, the variables themselves are correlated. For example, repeaters are significantly older than nonrepeaters (mean ages 9.3 and 8.4 years, respectively; $t = 7.98$, $p < .01$) and rural students are older than urban students (mean ages: rural, 9.0 years; municipal, 8.9 years; urban, 8.4 years; $F = 12.8$, $p < .01$). The correlation between days attended and posttest score is .24 and that between posttest score and age is .34. Thus these variables do not act independently in their relation to student flow.

We therefore turned to regression analyses, which examine the significance of these variables as linear predictors of passing. Except for **RURAL**, these variables are likely to take on different values within a classroom and thus potentially influence a teacher's pass-fail decision. Specifically, the teacher is supposed to consider a student's attendance record and achievement level; as we have seen, we suspect the teacher also attends to repetition history and age.

Jamison (in chap. 7 of this volume), investigating determinants of repetition and dropout, analyzed the 1975 data using a set of recursive linear regression equations. Jamison's model used all of the school, teacher, and student variables and postulated a causal ordering of these variables. Our analysis differs from Jamison's in that we have kept the number of independent variables small and have introduced interaction terms. Using fewer variables makes regression coefficients more interpretable and increases the stability and hence the predictive capacity of the model. The multiplicative effects of

TABLE 18

Comparison of Rural Students from Farm and Nonfarm Families: 1974

| | Farm | Nonfarm | $t$ |
|---|---|---|---|
| Mean age in years | 9.0 | 8.9 | .47 |
| Mean number of days attended | 121.2 | 123.1 | .35 |
| Mean distance walked to school in meters | 792.7 | 732.0 | .70 |
| Mean posttest score | 32.4 | 34.6 | 1.28 |

variables apparent in the earlier analysis suggested the inclusion of interaction terms.

Table 19 summarizes the results of our most revealing regressions. The model fitted in each case is of the form

$$Y = \beta_0 + \beta_1 X_1 + \cdots + \beta_m X_m + \beta_{12} X_1 X_2 + \beta_{13} X_1 X_3 + \cdots$$
$$+ \beta_{m-1,m} X_{m-1} X_m + e$$

where $Y$ is the probability of passing and the $X$s are the independent variables. Sample sizes vary for each regression according to the number of complete observations for the relevant variables. The interaction terms $X_i X_j$ were computed as the product of variables and were labeled with two letters from each variable in the product; for example, **AGDA** is the product of **AGE** and **DAYS**. $R^2$, the square of the sample multiple correlation coefficient, is given as a measure of the strength of the model. Stepwise regression was used. The results for the first and final steps are given together with the order of entry of the variables.

Let us for the moment restrict our attention to Models 1 through 4 (Table 19), since Models 5 through 8 are these same models without interaction terms and are provided merely for comparison. Models 2, 3, and 4 differ from Model 1 in that they include **POST**, **RURAL**, and both **RURAL** and **POST**, respectively, together with interaction terms as independent variables. Because of missing values, the sample sizes in Models 2, 3, and 4 were drastically reduced. The deletion of so many observations can be misleading. For example, it was at first puzzling to observe that the $R^2$ for Model 1 was larger than that for Model 2—that the addition of another variable should give us a worse fit and make prediction less reliable. Closer examination revealed that the estimated correlation coefficient of passing with **DAYS** was .499 in the Model-1 sample and only .293 in the Model-2 sample. This is

TABLE 19

Regression Results from Various Models: 1974

| Regression number | Description |
|---|---|
| 1 | Linear model on **PASS** with **AGE**, **DAYS**, **REPT**, and interactions<br>Number of observations = 992<br>Step 1: **AGDA**, $R^2 = .2568$, $\beta = .00056$, $F = 342$<br>Order of entry: **AGDA**, **DAYS**, **DARP**, **REPT**, **AGRP**, **AGE**<br>Final step: all in, $R^2 = .2817$ |
| 2 | Linear model on **PASS** with **AGE**, **DAYS**, **REPT**, **POST**, and interactions<br>Number of observations = 659<br>Step 1: **PODA**, $R^2 = .2338$, $\beta = .00010$, $F = 200$<br>Order of entry: **PODA**, **AGE**, **POST**, **AGDA**, **POAG**, **REPT**, **PORP**, **AGRP**, **DARP**, **DAYS**<br>Final step: all in, $R^2 = .2608$ |
| 3 | Linear model on **PASS** with **AGE**, **DAYS**, **REPT**, **RURAL**, and interactions<br>Number of observations = 659<br>Step 1: **DAYS**, $R^2 = .2470$, $\beta = .00419$, $F = 215$<br>Order of entry: **DAYS**, **AGDA**, **RURAL**, **AGRP**, **DARP**, **AGE**, **REPT**<br>Final step: all in, $R^2 = .2786$ |
| 4 | Linear model on **PASS** with **AGE**, **DAYS**, **REPT**, **POST**, **RURAL**, and interactions<br>Number of observations = 433<br>Step 1: **PODA**, $R^2 = .2521$, $\beta = -.00004$, $F = 145$<br>Order of entry: **PODA**, **AGDA**, **PORP**, **DARP**, **AGE**, **POST**, **POAG**, **RURAL**, **DAYS**, **REPT**, **AGRP**<br>Final step: all in, $R^2 = .2873$ |
| 5 | Linear model on **PASS** with **AGE**, **DAYS**, **REPT**<br>Number of observations = 992<br>Step 1: **DAYS**, $R^2 = .2487$, $\beta = .00587$, $F = 327$<br>Order of entry: **DAYS**, **AGE**, **REPT**<br>Final step: all in, $R^2 = .2715$ |
| 6 | Linear model on **PASS** with **AGE**, **DAYS**, **REPT**, **POST**<br>Number of observations = 659<br>Step 1: **POST**, $R^2 = .2048$, $\beta = .01624$, $F = 169$<br>Order of entry: **POST**, **DAYS**, **AGE**, **REPT**<br>Final step: all in, $R^2 = .2474$ |

(Table 19, cont.)

| Regression number | Description |
|---|---|
| 7 | Linear model on **PASS** with **AGE**, **DAYS**, **REPT**, **RURAL**<br>Number of observations = 659<br>Step 1: **DAYS**, $R^2 = .2470$, $\beta = .00634$, $F = 215$<br>Order of entry: **DAYS**, **AGE**, **RURAL**, **REPT**<br>Final step: all in, $R^2 = .2767$ |
| 8 | Linear model on **PASS** with **AGE**, **DAYS**, **REPT**, **POST**, **RURAL**<br>Number of observations = 433<br>Step 1: **POST**, $R^2 = .2058$, $\beta = .01579$, $F = 111$<br>Order of entry: **POST,DAYS,AGE,REPT**<br>Final step: all in, $R^2 = .2683$ |

reasonable, since students with very low attendance were less likely to take the posttest (some, in fact, had dropped out) and hence were underrepresented in the Model-2 sample. Thus, the range and predictive power of **DAYS** were reduced in Model 2.

The interaction terms proved to be revealing in fitting the regression model. In all cases but one, an interaction term entered in step 1; that is, it was the best single linear predictor of passing in the model. Perusing the order of entry of terms into each model shows that the interaction terms overall played as significant a role in fitting as the original variables. We should interpret this observation to mean that our variables are working together to exert effects at least as strong as those they exert independently. Furthermore, the models with interaction terms give a much better feel for the relative importance of variables than do Models 5 through 8. It is interesting to note that in Model 8, **RURAL** did not even enter, whereas in Model 4, inclusion of interactions brought in all variables.

The interactive models make it clear that **AGE**, as we suspected, is a good predictor of passing, either by itself or as part of an interaction. Indeed, in Models 1, 3, and 4, **AGDA** entered the regression on step 1, and in Model 2, **AGE** entered on step 2. Similar effects of **AGE** can be observed in the other models.

The range of $R^2$ was from .26 to .29 for our models, which means that the models account for about a quarter of the variability in the sample. Although these values are not high, they are large enough to give us confidence that our variables have explanatory power. The interaction terms improved the fit of the models, but only slightly.

The relatively poor fit of the models suggests that if we want to assess further and understand the determinants of repetition, we should consider new models. One alternative, more appropriate for predicting the occurrence of an event from many variables, is the logarithmic linear model. Although we expect to obtain a better fit, it is unlikely that using the logarithmic linear model will lead to different conclusions, since it is similar to the linear model in considering effects as additive. The significance of the multiplicative interaction terms discussed above suggests that the next step is to consider a model that emphasizes the multiplicative effects of the independent variables. Toward this goal we are presently working on stochastic models to predict the probability of passing.

## 3. THE 1975 FIRST-GRADE STUDENT DATA

We turn our attention now to the 1975 data, recalling that these students are of interest because they used the Radio Mathematics Project lessons but also bearing in mind that they were not randomly selected and the findings must be interpreted cautiously. These data are also useful in that the students were administered a mathematics pretest. (The pretest is described fully in Searle, Friend, & Suppes, 1976.)

### *Patterns of Student Flow*

Table 20 presents the progression patterns for the 1975 first-grade students. There was no record of any students gaining entry to second grade by taking and passing the retests, so that category has been eliminated. In general, the results are quite similar to those shown in Table 11 for 1974.

Table 21 presents flow outcomes for the 1974 and 1975 student groups and also for the radio and nonradio students of 1975. Contrasting the 1974 and 1975 samples, about 5% more students were promoted in 1974 and about 4% fewer dropped out; the repetition rate was the same. In 1975, the radio group had a slightly lower repetition rate and a slightly higher dropout rate than the traditional group had. Although the differences between the radio and the traditional groups are suggestive, we will not pursue them further here because the nonrandom selection of the radio students makes interpretation difficult.

**Relation between flow and pretest score.** In the analysis of the 1974 data we used the mathematics posttest score as a proxy for achievement or ability level. However, using a posttest score suffered

TABLE 20

Progression Patterns for First-grade Students: 1975

| Outcome[a] | *N* | % | *N* | % |
|---|---|---|---|---|
| Promotion | | | 408 | 42.9 |
| Passed finals, enrolled in Grade 2 | 384 | 40.4 | | |
| Failed finals, no record of retest, enrolled in Grade 2 | 24 | 2.5 | | |
| Repetition | | | 276 | 29.0 |
| Failed finals, enrolled in Grade 1 | 150 | 15.8 | | |
| Passed finals, enrolled in Grade 1 | 28 | 2.9 | | |
| Did not take finals, enrolled in Grade 1 | 98 | 10.3 | | |
| Between-year dropout | | | 253 | 26.6 |
| Failed finals, did not enroll | 39 | 4.1 | | |
| Passed finals, did not enroll | 69 | 7.3 | | |
| Did not take finals, did not enroll | 145 | 15.2 | | |
| Unknown pattern | | | 14 | 1.5 |
| No record of finals, enrolled but grade unknown | 14 | 1.5 | | |
| TOTAL | 951 | | | |

[a] Performance on finals in 1975, enrollment in 1976

the defect that students who dropped out of school during the year did not take the test. Therefore, it is of great interest to relate flow outcomes to the score on the mathematics pretest administered in 1975. (We did not perform the entire analysis—relating all the variables to flow outcomes—on the 1975 data because these classes were not randomly selected.) As described earlier for other continuous

TABLE 21

Flow Outcomes: 1974 and 1975

| Outcome | Percentage of students | | | |
|---|---|---|---|---|
| | All 1974 | All 1975 | Radio 1975 | Traditional 1975 |
| Promotion | 47.4 | 42.9 | 42.7 | 43.3 |
| Repetition | 29.8 | 29.0 | 27.7 | 31.6 |
| Dropout | 22.7 | 26.6 | 27.5 | 24.8 |
| Unknown | .2 | 1.5 | 2.1 | .3 |

variables, students were divided into three groups by pretest score: low (score less than 18), middle (18–22), and high (23–28). The percentages of students in each group were, respectively, 21%, 41%, and 37%.

Figure 7a presents the flow outcomes for all students by pretest score level. The percentage of students promoted rises sharply with pretest score and the percentage repeating falls. The percentage dropping out is essentially unrelated to pretest score. This finding strengthens the conclusion drawn from the 1974 data that dropping out is unrelated to achievement level. We can state now with greater confidence that, for this sample of students, low-ability students do not drop out more frequently than high-ability students.

Outcomes for nonrepeaters and repeaters are compared in Figures 7b and 7c. Once again we see that repeaters are promoted more often than first-time students, regardless of ability level. In fact, for the low-scoring repeaters, a higher percentage of students is promoted than repeats—a situation found for no other low-scoring subpopulation studied.

Figures 7d and 7e compare the urban and rural subpopulations. The patterns are roughly the same, but both dropout and repetition appear to be more sensitive to pretest score in the rural population than in the urban. Thus, for urban students, 43% of the middle scorers were promoted and 34% repeated. For the rural students these percentages were 58% and 28%, respectively.

### *Comparison of Radio and Traditional Students*

Of the variables we have been discussing, radio use is strongly related to only two—achievement[3] and attendance. Table 22 presents evidence that radio students perform better than traditional students on the project mathematics posttest. The table also presents the test scores separately for students in the three pretest groups. This latter comparison shows that radio students at all ability levels (as measured by the pretest) scored higher than traditional students on the mathematics posttest.

Table 23 presents this result in another way by recording the percentages of traditional students and radio students that fall into the low, middle, and high posttest groups. Only 23% of the radio students, as compared with 52% of the traditional students, fall within the low-scoring group. Thus, the project lessons had a substantial

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[3] A mathematics posttest again serves as a proxy for achievement. The test is different from that used in 1974. It is described in Searle et al. (1976).

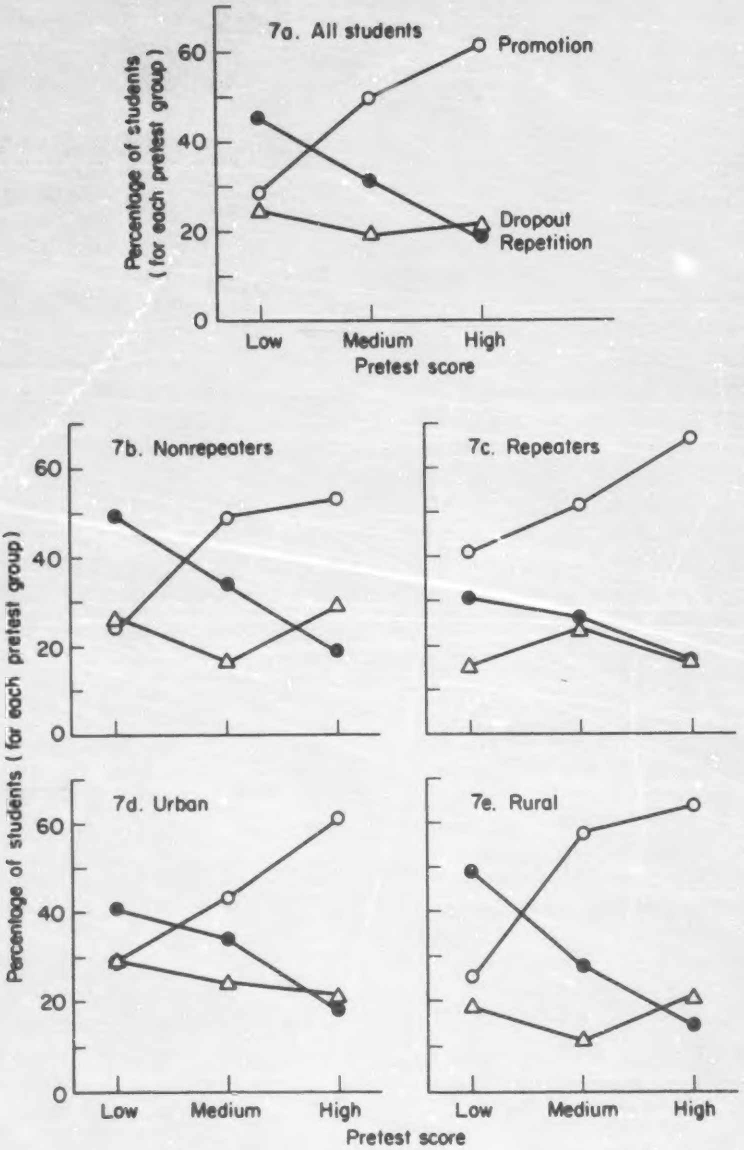

FIGURE 7. Relation between flow outcomes and pretest score for several populations, 1975 sample.

TABLE 22

Posttest Performance for
Radio and Traditional Students
Grouped by Pretest: 1975

| Pretest score | Mean posttest score | | |
|---|---|---|---|
| | Traditional | Radio | All |
| All | 50.2 | 59.2 | 55.9 |
| Low ( < 18) | 40.3 | 47.2 | 49.4 |
| Middle (18–22) | 46.7 | 60.9 | 55.8 |
| High ( > 22) | 57.7 | 65.3 | 62.7 |

TABLE 23

Distribution of Radio and Traditional
Students by Posttest Score: 1975

| Posttest score | Percentage of students | |
|---|---|---|
| | Traditional | Radio |
| Low ( < 52) | 51.6 | 22.5 |
| Medium (52–64) | 26.5 | 39.0 |
| High ( > 64) | 21.9 | 38.6 |

impact in raising student scores from the very low levels found in the traditional group.

Finally, we report on the attendance records for radio and traditional students. As shown in Table 24, radio students had poorer attendance records than traditional students. (Because of the nonrandom selection of classes we are unsure whether this finding is replicable.) The rather substantial difference in mean number of days attended is reduced when the population is restricted to those students who did not drop out during the year, suggesting that some of the difference can be attributed to the higher dropout rate for radio students noted in Table 21. It is interesting to note that achievement gains of radio students as compared with traditional students were obtained despite the poorer attendance record of the radio students.

TABLE 24

Attendance for Radio and
Traditional Students: 1975

| Group | Mean number of days attended | |
|---|---|---|
| | Traditional | Radio |
| All students | 141.2 | 126.6 |
| Excluding within-year dropouts | 153.1 | 147.1 |

## 4. SUMMARY AND DISCUSSION

We can summarize the major findings of this study along several dimensions. We will look first at the patterns of flow in the entire population, then identify differences between the school locations, and finally compare first-time and repeating students.

### *Patterns of Flow*

There are three outcomes for children in first grade: promotion, repetition, and dropping out. We discuss each in turn.

**Promotion.** We found that age and achievement are both strongly related to promotion. Students who are older or who have higher test scores are more likely to be promoted. The relationship to attendance is not so strong: Although those in the low attendance group fare poorly, there is little difference between those in the middle and high attendance groups. Perhaps the most striking finding is the power of the **AGE** variable to predict promotion. We illustrate this in Table 25, which reports the percentage of children promoted in each age group

TABLE 25

Relation Between Promotion and Age for
Middle Achievement and Attendance Groups: 1974

| Age | Percentage of students promoted | |
|---|---|---|
| | Middle achievement group | Middle attendance group |
| Younger than 8 years | 48.2 | 34.5 |
| 8 years | 55.6 | 53.4 |
| Older than 8 years | 61.3 | 65.8 |

when the population is restricted first to those in the middle achievement group and then to those in the middle attendance group. For these groups of "average" students, the percentage promoted rises with age, from 48% to 61% for the middle achievement group and from 35% to 66% for the middle attendance group. The effect of age is surely interacting with the effect of repetition history (repeaters are older and more likely to pass) but can be demonstrated even when the population is further restricted to nonrepeaters. Thus, it appears that when teachers make pass-fail decisions they give preference to older students.

**Repetition.** We identified three routes to repetition. Some students who returned to first grade did not take the final examinations, some failed the finals, and some, even though they passed the finals, returned to first grade the following year. Three percent of one sample and 5% of the other fell into this last category. Robinson (1977), reporting on an extensive analysis of the education sector in El Salvador, identified the same three types of repeaters. The sector analysis examined the full range of primary grades and attributed the repeater-passer pattern to the nonexistence in the school of the next school grade. (For example, if a school has no fifth grade, children who pass fourth grade and want to remain in school must repeat.) However, this explanation cannot hold for the Nicaraguan sample of first graders because all schools in the sample had a second grade. We have not yet investigated this small but interesting category of students.

Repetition was found to be inversely related to age, achievement, and attendance, as might be expected. It will be of great interest to examine more closely the three types of repeaters and in particular to examine their ability levels as measured by pretest (before students have dropped out). That analysis will be done with the 1976 data, for which classes were both randomly selected and pretested.

**Dropping out.** Two types of dropouts were identified: between-year and within-year dropouts. Approximately 20–25% of each sample are within-year dropouts. As seen in Tables 11 and 20, approximately 10% of each sample drop out within the year and then return to school the next year. Another 10–15% drop out within the year and do not return. These are then included in the between-year dropout category. Robinson (1977) reports a similar classification for the El Salvador population of primary-school students (all grades). For that system, approximately 10% of the population drops out within the school year and half of these return to school the next year. For the Nicaraguan first-grade sample, the within-year dropout rate was double, about 20%, but, as in El Salvador, half of these returned to school the next year.

The most surprising finding related to dropping out is that the rate is relatively insensitive to achievement level, as measured by the mathematics pretest or posttest. The rate is also insensitive to age. About one-quarter of each sample was classified as between-year dropouts; the range among age groups and among pretest groups was only from 19% to 25%. Our expectation that older students and students of lower ability would be the most likely to drop out was not supported by the data. We clearly must consider new variables to better understand the antecedents of dropping out.

### *Nonrepeaters and Repeaters*

As we have seen, repeaters—who constitute about 35% of the 1974 sample—have a better prognosis than nonrepeaters. They are more likely to be promoted, less likely to repeat, and less likely to drop out. They are, on the average, older (9.3 vs. 8.4 years), score higher on the posttest (39.6 vs. 35.1), and have a better attendance record (136.1 days attended vs. 132.5). Thus, although repeating represents a cost to the system, the students who repeat will not find themselves at a disadvantage. (One can hypothesize that these children have a better prognosis because they are motivated enough to return to school after an initial failure.) Repeating is wasteful not only for the system but for the students as well. However, because it occurs so frequently it is not likely to carry the stigma that is common in the United States. It is important that we recognize that the phenomenon has a different character in Nicaragua and undoubtedly in other developing countries as well. It is unlikely that conclusions drawn from research in the United States will be applicable to these populations.

### *Rural and Urban Students*

Rural students are less likely to be promoted, more likely to repeat, and less likely to drop out than urban students. This last finding is contrary to the national figures presented in Table 1. The national figures refer to all grades in the rural schools. In retrospect, it seems not unlikely that the situation for first grade is different. Perhaps parents in rural areas see the first year as providing the fundamentals of literacy and numeracy and make a greater effort to see that children complete first grade. Because more than 50% of the rural children in school are in first grade (Table 1), it seems appropriate to examine patterns for these children separately from entire-school averages.

We found (Fig. 3) that both promotion and repetition are much more sensitive to age in rural schools than in urban schools; that is, young rural students are much more likely to repeat and much less likely to be promoted than young urban students. Promotion and repetition are also more sensitive to achievement levels (as measured by the mathematics posttest) in rural schools as compared with urban schools (Fig. 6). Thus, rural low-scorers are more likely to repeat and less likely to be promoted than urban low-scorers. At the other end of the achievement scale, rural high-scorers are less likely to be promoted and more likely to repeat than urban high-scorers. Looked at another way, we can say that for a given test score, the outcome is more favorable for the urban student than for the rural student. It seems that teachers tend to judge rural students more harshly than they judge urban students, perhaps reflecting lower expectations for these students.

### *Radio and Traditional Students*

We have reported here only preliminary results for students studying mathematics by radio. Because the samples were not taken randomly, we are reluctant to draw any inferences about how these students compare with traditional students. One finding that has already been replicated with data collected in 1976 is that radio students at all ability levels score higher on the mathematics posttest than do traditional students. We intend with the 1976 data to study further the impact of the radio instructional program on student flow.

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# *Chapter 9*

# EDUCATION DECISIONS AND COST ANALYSIS FOR THE RADIO MATHEMATICS PROJECT IN NICARAGUA

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IN THIS CHAPTER we undertake to summarize our experience in resource costs and to analyze the impact on costs of several basic decisions for the Radio Mathematics Project in Nicaragua. The four main decisions discussed here concern the rate of implementation of the project throughout the country, the extension of the project to higher primary grade levels, staffing alternatives for production of programs, and the choice between rented radio-transmission time and ownership of a transmission system by the Ministry of Public Education.

In the first section we describe briefly the primary-education system of Nicaragua (with data drawn from education ministry surveys) and the Radio Mathematics Project. In the second section we describe the cost-analysis methodology that we use to analyze project decisions, and then discuss the decisions in more detail. In the third section we present the cost data used for the analysis and discuss assumptions that were necessary for projections of costs. The final section contains the analysis of the cost data and the conclusions we drew from it.

We wish to emphasize at this point, as we will again later in the paper, that cost analysis in isolation is not sufficient for educational decision making in most circumstances.[1] We must be concerned with

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[1] Of the decisions we analyze, only the decision between owning and renting transmission facilities may be made through cost analysis alone, and even this is questionable, as there are likely to be different structural impacts and opportunities for each alternative.

### TABLE 1
### Population, School Enrollment, and Rural Schools by Department

| Department | Population of 7 to 12 year olds in 1972 | Percent of pop. incr., 1970–1972 | Percent of 7 to 12 year olds enrolled in 1970 | Percent of 7 to 12 year olds enrolled in 1972 | Increase in percent of 7 to 12 year olds enrolled 1970–1972 | Number of schools | Percent schools in rural areas |
|---|---|---|---|---|---|---|---|
| Boaco | 17,615 | 4.6 | 30.5 | 35.1 | 20.5 | 66 | 75.7 |
| Carazo | 14,174 | 2.9 | 80.9 | 93.8 | 19.3 | 141 | 72.3 |
| Chinandega | 29,737 | 6.1 | 69.9 | 70.9 | 7.6 | 195 | 66.1 |
| Chontales | 18,693 | 5.4 | 37.2 | 39.0 | 10.5 | 76 | 77.6 |
| Estelí | 16,868 | 6.6 | 71.4 | 76.1 | 13.7 | 140 | 86.4 |
| Granada | 14,656 | 3.5 | 73.1 | 73.8 | 4.4 | 101 | 6.3 |
| Jinotega | 19,639 | 5.1 | 41.2 | 42.5 | 8.4 | 147 | 91.8 |
| León | 33,314 | 3.2 | 70.0 | 65.7 | −3.3 | 203 | 74.4 |
| Madriz | 11,569 | 5.1 | 52.2 | 52.3 | 5.3 | 93 | 86.0 |
| Managua | 75,469 | 8.6 | n.a.[a] | 98.8 |  | 282 | 42.5 |
| Masaya | 16,428 | 1.9 | 78.3 | 82.0 | 6.7 | 113 | 57.5 |
| Matagalpa | 41,366 | 3.3 | 37.2 | 39.0 | 10.5 | 184 | 84.2 |
| Nueva Segovia | 11,186 | 7.5 | 44.2 | 51.8 | 26.0 | 70 | 77.1 |
| Río San Juan | 3,842 | 7.5 | 34.4 | 41.7 | 30.2 | 40 | 90.0 |
| Rivas | 14,583 | 3.9 | 71.8 | 77.1 | 11.6 | 118 | 78.0 |
| Zelaya | 20,764 | 3.8 | 63.5 | 68.3 | 11.6 | 165 | 70.3 |
| TOTAL | 359,903 | 5.2 | 66.3 | 67.6 | 7.3 | 2,129 | 72.0 |

*Note.* Compiled from Ministry of Education Statistics.

[a] n.a. = not available

the effect of decisions on educational outcomes and, eventually, with the relation of educational outcomes to social outcomes.

## 1. THE EDUCATIONAL SYSTEM OF NICARAGUA AND THE RADIO MATHEMATICS PROJECT

There are several major concerns to planners of primary education in Nicaragua:

1. Increasing school-age population;
2. Low but increasing participation rates;
3. High dropout and repetition rates;
4. Wide disparity between urban and rural classrooms.

In Table 1 we present population and enrollment statistics for each department in the country. The table also contains information regarding the percentage of rural schools in each area. As we can see, the population of school-age children (7 to 12 years old) increased by 5.2% from 1970 to 1972 to a total of 359,903 students. This growing population is increasing the demand for educational services. The social demand for education is also reflected in participation rates, which have risen from 66.3% (of school-age children) in 1970 to 67.6% in 1972. Although the population grew by 5.2%, the number enrolled increased by 7.3%. In general, all departments in the country had increases in population (1.9% to 8.6%) with even higher increases in the number of enrolled students (4.4% to 26.0%, except for one department having a 3.3% decrease).

In 1972, 305,690 students were enrolled in Nicaraguan elementary schools. Of these, 243,461 were in the 7- to 12-year age group. Of the remaining 62,229 students, most were over 12 years old. This figure reflects the high repetition rates, which are presented in Table 2 along with promotion and dropout rates for each grade level. As one can see from the table, the dropout and repetition rates are rather high. From the first to the second grade, 24.3% of all the preceding year's first-grade students leave school. It is not clear from the statistics whether the students who do leave school are first-grade repeaters or new students. (This issue is discussed further in chapter 8.) While the promotion rates increase as one moves to the higher grades, fewer than 20% of the students ever complete all six grades and of these a still smaller percentage completes all six grades with no repetitions.

The final problem we mention is the disparity between urban and rural classrooms. In Table 1, we notice a general relation between the percentage of rural schools and school-age participation rates: Rural areas tend to have lower participation rates. Unfortunately, data that

TABLE 2

Dropout, Promotion, and Repetition Rates by Grade Level, 1972

| Grade | Enrollment | Percent dropout during school year | Percent dropout after failing exams | Percent repetition | Percent promotion |
|---|---|---|---|---|---|
| 1 | 115,153 | 24.3 | | 17.2 | 58.3 |
| 2 | 60,385 | 17.1 | 1.2 | 13.3 | 68.4 |
| 3 | 45,461 | 15.7 | 1.8 | 12.3 | 70.2 |
| 4 | 35,770 | 14.8 | 4.2 | 10.3 | 70.7 |
| 5 | 27,600 | 13.2 | 7.1 | 7.4 | 72.3 |
| 6 | 21,321 | 10.5 | 6.7 | 4.2 | 78.6 |

*Note.* Compiled from Ministry of Education Statistics.

would enable us to separate dropout and repetition rates for rural and urban areas were not available.

Table 3 further exhibits the differences between rural and urban areas. Of the 7,608 teachers employed in public and private schools, 5,482 teach in urban areas. Of the urban teachers, 1.9% teach in classrooms with two grades and 1.8% teach in classrooms with three or more grades. Of the 2,126 rural teachers, 10.7% teach classes with two grades and 55.4% teach classes with three or more grades. We see further discrepancies in the statistics for students. Of all rural students, 51% are in classes of more than 35 students. The average class size, ignoring those situations where double sessions exist, is 56.3 students. Only 1.8% of urban students are in classes with more than 35 students. There are approximately twice as many urban students as rural students.

Other statistics of interest are the following: 72% of the schools are rural and only 13% of these have all six grades, whereas 81% of the urban schools have all six grades. In rural areas, 81% of the schools have only one teacher (4.4% in urban areas).

The familiar yet troubling educational issues in Nicaragua have prompted concern and some experimentation. The Radio Mathematics Project has been introduced with the aim of improving the learning of primary-school mathematics. If repetition rates are related to abilities of students, then improvements in mathematics learning may reduce repetition rates. While much of the dropout problem may be attributed to economic factors or to irrelevance of the curriculum, that portion which may be related to failure to learn may be reduced through improvements in the curriculum. A potential advantage seen for the radio broadcasts is to reduce the burden of the teachers in multigrade classrooms by providing instruction for some students and freeing the teacher to work more closely with more homogeneous groups of students.

As described earlier in chapter 2, the daily mathematics lessons consist of a radio portion and and postbroadcast portion taught by the classroom teacher. In the cost estimates presented below we do not distinguish between radio and nonradio portions of the mathematics curriculum production, as the effort is directed toward developing a complete curriculum consisting of two types of delivery systems. Therefore, it is not possible to know the cost of producing radio mathematics lessons unless we make some additional assumptions about efforts devoted to both components of delivery. We do, however, present separately the cost figures for studio time for recording of lessons, for radio transmission, and for radio reception.

## 2. COST ANALYSIS FOR DECISIONS

### *Description of the Cost Methodology*

There are several cost methodologies that can be used to estimate costs for instructional technology systems, of which we briefly describe

TABLE 3

Distribution of Teachers and Students in Urban and Rural Areas According to Number of Grades in One Classroom

| Category | Number of grades in classroom | | | | | | |
|---|---|---|---|---|---|---|---|
| | Total number | One grade | | Two grades | | Three or more grades | |
| Urban teachers | 5,482 | 96.3% | | 1.9% | | 1.8% | |
| Rural teachers | 2,126 | 33.9% | | 10.7% | | 55.4% | |
| Urban students | 213,865 | 96.0% | | 1.8% | | 2.2% | |
| Rural students | 100,560 | 32.8% | | 10.0% | | 57.2% | |
| Urban students in class of: | | | | | | | |
| 35–50 students | 106,584 | 51.9% | (41.4)[a] | .4% | (40.3) | .5% | (40.7) |
| > 50 students | 52,779 | 23.6% | (54.5) | .8% | (60.2) | 1.3% | (68.2) |
| Rural students in class of: | | | | | | | |
| 35–50 students | 34,190 | 9.3% | (41.8) | 3.9% | (41.8) | 20.3% | (41.6) |
| > 50 students | 52,392 | 17.1% | (68.3) | 4.3% | (61.4) | 30.7% | (66.0) |

*Note.* Compiled from Ministry of Education Statistics.

[a] Average class size in parentheses, ignoring double sessions.

two.[2] The first method consists of estimating costs for a single year of the project. Annualized values are used for capital costs (an annual cost for items that have a useful life beyond one year, such as radio receivers and buildings) and actual expenditures for recurring costs (expenditures for items used in the academic year, such as personnel salaries and rent). This method sometimes provides a reasonable approximation of annual project costs. However, in the case of the Radio Mathematics Project, in which there are heavy initial investment costs in curriculum development and increasing numbers of students using the curriculum from year to year, a more appropriate method is one that takes account of fluctuating costs and utilization. This method allows the decision maker to view costs from different time perspectives.

Before implementing the project, one would want to consider the entire pattern of costs and utilization. However, once the curriculum is developed, the cost is sunk in that the money has been spent, cannot be recovered, and hence is irrelevant for future decisions. The cost formula used in this method is

$$AC_{ij} = \frac{\sum_{k=i}^{j} \frac{C_k}{(1+r)^{k-i}}}{\sum_{k=i}^{j} \frac{N_k}{(1+r)^{k-i}}} \quad \text{for } j \geq i$$

where

$AC_{ij}$ is the average cost per student from year $i$ to year $j$;

$C_k$ is the cost of the project in year $k$ (actual incurred expenditures for capital and recurring items);

$N_k$ is the number of students enrolled in the program in year $k$;

$r_k$ is the interest rate.

By setting $i = 1$ and $j \geq i$ one may find average costs from the inception of the project to different points in the future. The use of this method will become clearer in the analysis of data presented later in this chapter. However, it is necessary to point out that costs are given in terms of constant dollars. Potential inflation is not included in cost estimates, as inflation affects only budget allocations and would distort comparability of cost figures among project years. The interest rate is included as a representation of the social preference for obtaining benefits in the present and paying costs in the future. One may also view the interest rate as representing the social opportunity cost of the particular investment chosen. That is, there are alternative investments with a rate of return equivalent to the interest rate used.

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[2] More complete descriptions of these and other methodologies may be found in Jamison, Klees, and Wells (1976) and Wells (1976).

### *Education Decisions in Nicaragua*

**Rate of implementation.** The curriculum for each grade level is tested on a small group of students during the development year. Once the curriculum has been developed, a decision must be made on the scheduling of implementation for the rest of the country. The cost of producing a one-year mathematics curriculum is high but fixed with respect to the number of students who utilize the curriculum. Therefore, the rapid implementation of the project would probably reduce average costs. However, implementing the project gives rise to additional total costs (teacher's guides, teacher training, radio batteries, and radio receivers)[3] and the appropriate pattern of implementation depends on the value attributed to additional educational opportunity.

Two factors further complicate this analysis. First, the production and the implementation of the program are funded from two different sources—the United States supports program production with some contribution from Nicaragua and the Nicaraguan government supports implementation. The U.S. government may prefer rapid implementation in order to lower average costs and to justify the initial investment, whereas the Nicaraguan government, with its responsibility for financing implementation, may prefer a less rapid alternative. Second, as implementation does involve expenditure of funds, the determining factor may well be the political allocation of funds and setting of budget levels. While the goal of reducing average costs makes it preferable to implement the project rapidly, budget constraints may lead to a slower schedule. In our analysis we demonstrate the effects on costs for different implementation schemes.

**Program production for other primary grades.** Programs have been produced for Grades 1 through 4 under AID sponsorship. The Nicaraguan government must decide whether to continue curriculum development beyond fourth grade. If the same patterns of enrollment, dropout, repetition, and promotion exist as in 1972 (Table 2), then average costs will probably be higher for upper grades. While radio receivers will already be in place, curriculum must still be developed and transmitter time rented. For both of these items the costs are independent of the number of students. A final decision on implementation in upper grades should depend on the potential benefits attributed to curriculum production for upper grades relative to the costs. In our analysis we describe only the costs of production and implementation in the various grade levels.

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[3] As there are so many more first-grade students than others, only the implementation of the first-grade programs will involve the purchase of new receivers. Rental costs of the transmission system do not increase dramatically for total-country coverage versus partial coverage.

**Staffing alternatives for program production.** Current curriculum-development costs are high because of the involvement of expatriates; high salaries and living allowances make it very expensive to support U.S. personnel in Nicaragua. Currently, the Americans play a major role in curriculum development and project management. We therefore analyze three staffing alternatives for one of the upper grade levels:

1. Expatriates remain for program production for all six grade levels;
2. Nicaraguans replace expatriates and a master curriculum plan is produced at Stanford;
3. Nicaraguan financial support remains at 1976 levels (expatriates are eliminated, not replaced) and a master curriculum plan is produced at Stanford.

Again, we emphasize that the potential impact of mathematics learning and other outcomes of concern should be estimated before a decision on staffing is made.[4]

**Ownership versus rental of transmission facilities.** At present, transmission time is donated by the Nicaraguan national radio network. However, as other grade levels are added to the production and as the project is implemented throughout the country, necessitating morning and afternoon broadcasts, it may be important to have a more secure access to transmission time. This could be achieved through rental or ownership of transmission facilities. Current rental is $35.70[5] per half hour for nationwide coverage. We provide approximate costs for the construction of a transmission facility to cover the entire country. However, a more detailed and accurate estimate would require a more extensive analysis of characteristics affecting transmission facilities peculiar to Nicaragua.

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[4] The potential benefits and costs of having Americans play an important role in Nicaraguan curriculum development are not examined except through the salary differential for expatriates and nationals, as above. Clearly, other aspects of this relationship are relevant to the choices above or alternatives to them.

[5] All costs in this paper are expressed in 1976 U.S. dollars. The exchange rate is $1(U.S. dollar) = C$7(Córdoba).

## 3. COST AND UTILIZATION DATA FOR NICARAGUA

In this section we provide a detailed discussion of the basic information we use to predict future costs and utilization patterns. Because the project has been in operation since 1973, the cost data are fairly precise. Uncertainty enters through the assumptions used for projections of cost and utilization. We shall be explicit for all of our assumptions. In the section on policy implications we discuss cases in which the assumptions may have substantial impact on costs. The remainder of this section is divided into subsections corresponding to major categories of data: utilization, start-up, administration, production, transmission, and reception.

Our first major assumption is that we treat this project as an addition to the normal educational system. That is, we do *not* include costs for teacher salaries, school buildings and equipment, or administration of the overall educational system.

### *Utilization*

For enrollment in each grade level we use 1972, for which data are presented in Table 2, as a base year. In the two-year period from 1970 to 1972 there was a 5.2% increase in school-age population. Hence, we assume an annual increase of 2.5% for each grade level, which is slightly lower than the annual compounded increase of 2.567% equivalent to a two-year 5.2% increase. Therefore, the number of students enrolled in any grade is given by

$$E_{gy} = E_{g1972}(1.025)^{(y-1972)} \quad \text{for } g = 1, 2, 3, 4, 5, 6$$

where $E_{gy}$ is enrollment in grade $g$ in year $y$ ($y$ is expressed in calendar years). These enrollment figures are for the beginning of the academic year; the dropout rate ranges from 24.3% in the first grade to 10.5% in the sixth grade. If the students drop out at the end of the academic year, it would be appropriate to include them in the estimates (which would decrease average costs); if the students leave school early in the year, it would be appropriate to exclude them (increasing average costs). We estimate costs by assuming that one-half of the students who leave school during the year do not receive the benefits of [illegible] mathematics curriculum and should be excluded from the analysis. This is a somewhat arbitrary assumption as it is not known at what point students actually do drop out. The appropriate reduction factors for grade-level enrollments are:

| Grade | Factor<br>(1/2 dropout rate) |
|---|---|
| 1 | .122 |
| 2 | .086 |
| 3 | .079 |
| 4 | .074 |
| 5 | .066 |

As these factors are applied to each year of the project it is relatively simple to modify the average-cost estimates to determine the impact of other reduction factors.

### *Start-up*

Start-up costs were incurred in 1974 both at Stanford and in Nicaragua; we report these separately. Similarly, we report project administration, summative evaluation, and curriculum development costs separately. While we do include all of the start-up costs, a decision must be made with respect to their allocation among cost estimates for the different grade levels. In our estimates we include these costs for the first grade only. It is possible that these costs should be allocated among the various grade levels, and in our analysis of costs we will discuss the impact of this allocation. The start-up costs incurred in 1974 are reported in Table 4. (Current dollar values have been converted to 1976 U.S. dollars with the assumption of an 8% annual inflation rate.)

### *Project Administration*

Project administration costs are incurred at Stanford and in Nicaragua. We consider two main activities under project administration—normal administrative functions and summative evaluation. Summative evaluation may be considered to be a research activity or part of the decision costs for potential project expansion. We keep these costs separate in our estimations for each grade level. Following estimations of work effort by project personnel, we divide costs incurred at Stanford by allocating 71% to summative evaluation, 24% to project administration, and 5% to curriculum development. In Nicaragua, 10% of general operating costs are allocated to administration, 15% to summative evaluation, and 75% to curriculum development. Salary costs in Nicaragua are assigned according to specific function. We include in our estimates the total salary paid to Nicaraguans, 44% of which is funded by the U.S. and 56% by the Nicaraguan government. (The precise breakdown varies with the individual.)

TABLE 4

1974 Start-up Costs

| | | | |
|---|---|---|---|
| STANFORD | | | |
| Travel | $ 8,326 | | |
| Expendable | | | |
| Office supplies | 1,899 | | |
| Books and publications | 513 | | |
| Postage | 301 | | |
| Telephone and telegraph | 1,655 | | |
| Equipment maintenance | 56 | | |
| Computer | 26,323 | | |
| Salaries | | | |
| Professional (28 person-months) | 45,516 | | |
| Research Assistant (12 person-months) | 11,617 | | |
| Secretary (6 person-months) | 4,687 | | |
| Benefits (16% and vacation) | 15,434 | | |
| Consulting | 3,079 | | |
| Total direct costs | | $119,406 | |
| Indirect costs (47%) | | 54,674 | |
| TOTAL STANFORD | | | $174,080 |
| NICARAGUA | | | |
| Travel | $ 7,917 | | |
| Expendable | | | |
| Office supplies | 3,732 | | |
| Books and publications | 886 | | |
| Postage | 5,960 | | |
| Telephone and telegraph | 126 | | |
| Equipment maintenance | 361 | | |
| Insurance | 1,044 | | |
| Field trips | 3,896 | | |
| Equipment | | | |
| Office furniture | 15,269 | | |
| Typewriters (4) | 2,600 | | |
| Calculators (2) | 800 | | |
| Automobiles (4) | 22,322 | | |
| Other | 2,090 | | |
| Salaries | | | |
| Expatriate (17 person-months) | 25,256 | | |
| Benefits (16% and vacation) | 6,757 | | |
| Moving allowance | 23,969 | | |
| School allowance | 3,266 | | |
| Living allowance | 22,039 | | |
| Nicaraguan (6 person-months) | 2,259 | | |
| Total direct costs | | $150,549 | |
| Indirect costs | | 46,340 | |
| TOTAL NICARAGUA | | | $196,889 |

We assume that summative evaluation takes place at Stanford in the year following the production of the program. For example, in 1975 a first-grade curriculum is produced and the summative evaluation for this grade level occurs in 1976. Summative evaluation expenses in 1975 (preparatory research) are included in costs for first grade. Second-grade curriculum development occurs in 1976 and summative evaluation takes place in 1977. However, in all cases the data are collected in Nicaragua, and we assume that summative evaluation expenses incurred in 1975 in Nicaragua are attributed to the first-grade curriculum, those occurring in 1976 are attributed to the second grade, and so forth.

We use 1976 data as base-year data for all of the following years. That is, the costs incurred in 1976 for producing the second-grade curriculum and evaluating the first-grade curriculum are assumed to be repeated in 1977 for third-grade curriculum production and second-grade evaluation—proceeding similarly for remaining years until all six grades are produced. Once all six grades are produced we assume a minimal staff for program revision and no Stanford involvement. The basic assumption is that the staff of 33 Nicaraguans and 3 expatriates is reduced to 10 Nicaraguans as summative evaluation and extensive curriculum development will no longer be necessary. We will analyze the cost impact of maintaining the staff at the 1975 level. A basic assumption we make with respect to continuation of the project is that every six years the curriculum for a given grade level is revised and all costs incurred in that year are included in the cost estimates of the curriculum for that grade level. For example, the first-grade curriculum is produced in 1975, summative evaluation is conducted in 1976, and portions of the curriculum are revised in 1981, 1988, and 1994. Similar projections are made for the other grades. Table 5 shows five major categories of data: administration and evaluation of the first grade in 1975 and 1976, administration and evaluation of all other grades for the first two years of analysis, and data for a typical revision year.

*Program Production*

The curriculum-development process includes substantial effort in planning the curriculum, writing scripts and teacher's guides, and weekly testing of students. The weekly tests are analyzed to determine potential modifications of the overall plans as the curriculum is developed during the course of the school year.

In Table 6 we report program-production costs for categories similar to those used in Table 5. However, as the expendable supplies

## TABLE 5

## Administration and Evaluation Costs

| Category | 1975 first grade production (ADM) | 1975 preparation for evaluation | Production year for Grades 2–6 (ADM) | Evaluation year for Grades 1–6 (Grades 2–6 for Nicaragua) | Typical revision year for all grades (ADM)[a] |
|---|---|---|---|---|---|
| STANFORD | | | | | |
| Travel | $ 255 | $ 753 | $ 439 | $ 1,298 | |
| Expendable | | | | | |
| Office supplies | 301 | 889 | 283 | 837 | |
| Books and publications | 24 | 71 | 139 | 410 | |
| Postage | 48 | 141 | 112 | 141 | |
| Telephone and telegraph | 124 | 365 | 151 | 365 | |
| Computer | 8,056 | 23,832 | 8,369 | 23,832 | |
| Salaries | | | | | |
| Professional | 8,122 | 24,028 | 10,042 | 29,708 | |
| Research Assistant | 3,098 | 9,165 | 774 | 2,290 | |
| Secretary | 1,448 | 4,283 | 2,237 | 6,619 | |
| Benefits | 2,799 | 8,281 | 3,273 | 9,683 | |
| Consulting | 598 | 1,769 | 724 | 2,140 | |
| Indirect costs (56%) | 13,930 | 41,211 | 14,864 | 43,972 | |
| NICARAGUA[b] | | | | | |
| Travel | 1,262 | 1,893 | 948 | 1,422 | |
| Expendable | | | | | |
| Office supplies | 1,692 | 2,538 | 3,084 | 4,626 | $2,544 |
| Books and publications | 30 | 45 | 22 | 33 | 16 |
| Postage | 219 | 329 | 308 | 462 | 254 |
| Telephone and telegraph | 79 | 119 | 142 | 213 | 117 |
| Utilities | 19 | 29 | 71 | 107 | 58 |
| Equipment maintenance | 285 | 428 | 504 | 756 | 416 |
| Insurance | 22 | 33 | 40 | 60 | 33 |
| Field trips | 18 | 26 | 60 | 90 | 37 |
| Equipment rental | 75 | 113 | 346 | 519 | 286 |
| Minor equipment | 100 | 150 | 100 | 150 | 82 |
| Rent | 342 | 513 | 342 | 513 | 282 |
| Salaries | | | | | |
| Expatriate | 13,753[c] | 4,470[d] | 13,753 | | |
| Benefits | 2,963 | 1,052 | 2,963 | 1,052 | |

(TABLE 5, cont.)

| Category | 1975 first grade production (ADM) | 1975 preparation for evaluation | Production year for Grades 2–6 (ADM) | Evaluation year for Grades 1–6 (Grades 2–6 for Nicaragua) | Typical revision year for all grades (ADM)[a] |
|---|---|---|---|---|---|
| Education allowance | 986 | 308 | 986 | 308 | |
| Living allowance | | 8,411 | 2,628 | 8,411 | 2,628 |
| Nicaraguan | 24,718[e] | 17,832[f] | 24,718 | 17,832 | 9,343 |
| Indirect costs (45%) | 21,421 | 12,159 | 22,210 | 12,490 | |

[a] For revision year, staff is cut to one-third. Comparably smaller facilities are assumed to be needed. Four of the remaining staff are assumed to spend 25% of their time on administration.

[b] Travel and expendable are allocated 10% administration, 15% summative evaluation, and 75% curriculum development. Salaries are allocated according to time spent on activity and salary of individual.

[c] 10 person-months.

[d] 3 person-months.

[e] 36 person-months.

[f] 50 person-months.

were allocated by a fixed amount among summative evaluation, administrators, and program production, we will not repeat the specific cost categories given in Table 5. One must also add the expenses for recording the lessons, which are as follows (170 lessons are produced for each grade level):

| | |
|---|---|
| Studio rental | $14.28/lesson |
| Recording artist | $42.85/lesson |
| Technician | $14.28/lesson |
| Tape | $ 3.70/lesson |

We further assume that 10% of the lessons are altered at one-half of the normal price to correct errors. In addition, estimated personnel time associated with recording is 3.7 person-years for actual writing of scripts, 1.0 person-years for typing of scripts, and .03 person-years for directing the recording. During 1975 and the first nine months of 1976 an expatriate was employed full time for directing program production. We also include preparation of teacher's guides as part of production costs (involving 1.25 person-months for writing and typing) since the guides are part of the total curriculum. However, the printing of these guides and the training of teachers are considered to be part of reception costs.

For periodic revisions we assume that 25% of the lessons are changed and that only a partial revision is made. In our analysis we demonstrate the impact on costs of a complete revision. For continuing revision we assume a personnel effort of 8.75 person-years compared with 17.65 person-years now (.95, expatriates; 11.45, observation and testing; 4.0, scriptwriting and production; 1.25, teacher's guides).

### *Transmission*

In 1975 the programs were not broadcast but were presented in 20 schools through cassette recorders, an investment of $2,000. Cassette tapes for these schools cost an additional $5,100. This would be a quite expensive means of transmission as the number of schools increase. Transmission time for coverage of the entire country may be leased for $35.70 per half hour or $6,069 for the 170 lessons. In our cost estimates we use the tape costs for 1975, a cost of $6,069 for radio

TABLE 6

Program Production Costs

| Category | Grade 1<br>1975 | Grades 2–6<br>1976–1980 | | Revision years<br>1981– |
|---|---|---|---|---|
| STANFORD | | | | |
| Travel | $ 53 | $ 92 | | |
| Expendable | 103 | 685 | | |
| Computer | 1,678 | 1,743 | | |
| Salaries | 3,347 | 3,695 | | |
| Indirect costs | 2,902 | 3,097 | | |
| NICARAGUA | | | | |
| Travel | 9,470 | 7,110 | | |
| Expendable | 21,615 | 37,645 | | $12,675 |
| Salaries | | | | |
| Expatriate | 34,253 | 30,239 | (18,197)[a] | |
| Benefits | 8,334 | 7,651 | ( 5,994) | |
| Education allowance | 2,406 | 2,106 | ( 2,086) | |
| Living allowance | 20,502 | 17,877 | ( 9,976) | |
| Nicaraguan | 80,974 | 80,974 | | 35,743 |
| Indirect costs (45%) | 45,919 | 49,957 | (43,792) | |
| Recording costs | 13,366 | 13,366 | | 3,088 |

[a] Numbers in parentheses are for 1977–1980 when one of the expatriates will have left the project.

transmission for each grade in the initial year of production, and $12,138 each year during which a grade-level curriculum is completely implemented to accommodate double sessions.

At present there is no direct charge for transmission time, as it is donated by the government-owned radio network. Time will probably be donated in 1977 and 1978 as well. However, if there are alternative uses for the time, one should include a cost for transmission because removal of transmission time from alternative uses may represent an opportunity cost in terms of forgone revenue to the government.

We compare the costs of transmission rental with transmission-system ownership in a later section of this paper.

### *Reception*

There are four major elements of reception costs: teacher training, teacher's guides, radio receivers, and battery costs. Teacher training is accomplished in two three-hour sessions. We assume a cost of $15 per teacher for these training sessions, which includes payment to the teachers for the time they spend in the sessions. However, it may not be necessary to pay teachers, who are often asked to attend meetings for which they are not compensated; in this case, the estimate of $15 per teacher is high.

Teacher's guides must be printed and distributed. The fixed cost for printing a 250-page guide is estimated to be $2,962[6] for plates, developer, glue, masking paper, film, fixer, and concentrate. The variable cost is $2.14 per copy for up to 100 copies and $1.75 per copy for runs over 100 copies. These variable printing costs cover paper, ink, cement, and cardboard paper. It is assumed that two weeks of labor are required for producing the plates and printing copies (a cost of $215). Once the plates are made, additional copies may be produced at variable cost only.

For each grade level we assume that the plates are produced in the year of the major implementation and in every revision year. Variable costs occur as copies are required. We assume 80 copies in the initial year of production, produced by photocopy at a cost of $10 per guide. In order to determine additional printing needs, we must calculate the total number of teachers at each grade level. We first assume that the supply of teachers will keep pace with the growth in student numbers (assumed to be 2.5% per year). We must then estimate the number of teachers for each grade level. In 1972 there was a total of 7,608 teachers. The estimated increase by 1975 was 8,193. Many teachers teach multiple grades and require a guide appropriate for each grade level. From 1975 data for three regions (mostly rural in character) the following estimates[7] were obtained:

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[6] Printing costs were estimated by Thomas Tilson, Assistant Project Director in Nicaragua.

| Grade | Percentage of all teachers with students at given grade level |
|---|---|
| 1 | 36.1 |
| 2 | 30.6 |
| 3 | 26.2 |
| 4 | 22.2 |
| 5 | 15.5 |
| 6 | 12.4 |

Therefore, we have the following numbers of teachers for the six grades in the year of widespread introduction:

| Grade | Year | Number of teachers |
|---|---|---|
| 1 | 1979 | 3,264 |
| 2 | 1978 | 2,700 |
| 3 | 1978 | 2,312 |
| 4 | 1979 | 2,008 |
| 5 | 1980 | 1,437 |
| 6 | 1981 | 1,178 |

If a 25% overrun of the teacher's guide is printed in each of these years, a sufficient number will be available to cover the 2.5% annual growth and possible replacements. If participation rates continue to climb, more teacher's guides and more radio receivers will be necessary.

As simultaneous broadcasts for different grade levels are not necessary and as there are far more students in the first grade than in the upper grades, we assume that providing enough receivers for all first-grade classrooms will result in a sufficient number of radios for all other grade levels. We therefore only need to know the number of first-grade teachers to know the number of receivers required. Receivers are assumed to cost $50 and batteries $1.50 for 10 hours of operation.[8] The battery cost is then $12.75 per year for each radio for each grade level. Assuming a radio requiring 4 watts and mainline electricity of $.10 per kilowatt-hour, the annual cost per grade level would be approximately $.05. It is clear that battery operation of the radios will have a significant impact on costs. In our analysis of implementation we compare costs for two different types of batteries and for mainline electricity. The first year for complete implementation for the first grade will be 1979, since programs in 1975 and 1976 involved the use of student worksheets (assumed to be half the size of the teacher's guides). These programs will be modified in 1977 and 1978 to eliminate the use of worksheets.

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[7] These estimates were made by Thomas Tilson.

[8] Both of these estimates are within the higher range of receiver price and battery life reported in *Consumer Reports*, July 1970, pp. 436–439. The estimates of battery life were obtained from the General Electric Company's test data comparing battery life for carbon-zinc, zinc-chloride, and alkaline batteries. Carbon-zinc batteries have the lowest initial purchase price and these are used in Nicaragua. Alkaline batteries would last 50 hours at a cost of about $4.50, or only $7.65 per grade level per year.

We assume further that radios are replaced every six years and that each year 10% of the radios are repaired at a cost of $15 per radio.

### *Summary*

We repeat here the major assumptions that we used for the analysis and that underlie the data in Tables 7 through 9.[9]

1. The radio system is an addition to the normal educational system, and we do not include in our analyses any of the costs associated with the regular system.
2. Student population grows at an annual rate of 2.5% for each grade level with no change in 1972 dropout or repetition rates. (With increasing participation rates this may be a conservative estimate.)
3. As students drop out during the school year we reduce initial enrollments by one-half of the dropout rate for each grade level (.122, .086, .079, .074, .066, and .053 for Grades 1 through 6, respectively).
4. All start-up costs incurred in 1974 at Stanford and in Nicaragua are included in cost estimates for the first grade.
5. Of the costs incurred at Stanford, 71% are allocated to summative evaluation, 24% to project administration, and 5% to curriculum development. The costs for summative evaluation in any one year are for evaluation of the grade-level curriculum created in the previous year and are included in the cost estimates for that curriculum.
6. Of the costs incurred in Nicaragua, 10% are allocated to administration, 15% to summative evaluation, and 75% to curriculum development. Salary costs are allocated according to the time spent on each activity by each individual and according to the salary of that individual.
7. Costs actually incurred in 1976 are used as the base-year data for comparing costs of the following years.
8. Curriculum for one grade is produced each year from 1975 to 1980,

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[9] We provide detailed cost breakdowns for the first and second grade in Tables 7 and 8, respectively. In Table 9 we provide summary cost information for all grade levels.

after which a staff of 10 continually revises each curriculum in a six-year cycle. The revision is assumed to consist of retaping 25% of the lessons and producing new teacher's guides.

9. Curriculum-development costs include all costs of preparing the mathematics curriculum, part of which is delivered by radio and part by the teacher. We do not separate these costs.
10. Ten percent of the lessons are revised at one-half the normal price to correct program errors.
11. Transmission time is rented at $35.70 per half hour (current commercial rates for nationwide coverage). We include this cost even though time is currently donated. For 1975, transmission involved the use of tape recorders.
12. Each curriculum is implemented as rapidly as possible. We use the following dates for nationwide implementation:
    1978–second and third grade
    1979–first and fourth grade
    1980–fifth grade
    1981–sixth grade
13. We assign costs of radio receivers to the first-grade cost estimate. The number of receivers is 55 in 1976 and 85 in 1977. In 1978 the number of receivers is that required in the second grade. For 1979 and beyond, the number of receivers is matched with the number of first-grade teachers, which increases at 2.5% per year.

TABLE 7

Cost and Utilization for First and Second Grade
(in U.S. 1976 Dollars)

| Category | Grade 1 | | | Grade 2 | | |
|---|---|---|---|---|---|---|
| | 1975 | 1976 | 1977 | 1976 | 1977 | 1978 |
| SUMMATIVE EVALUATION | | | | | | |
| STANFORD | | | | | | |
| Travel | 753 | 1,298 | | | 1,298 | |
| Expendable | 1,466 | 1,753 | | | 1,753 | |
| Computer | 23,832 | 23,832 | | | 23,832 | |
| Salaries | 47,526 | 50,440 | | | 50,440 | |
| Indirect costs | 41,211 | 43,972 | | | 43,972 | |
| NICARAGUA | | | | | | |
| Travel | 1,892 | 1,422 | | 1,422 | | |
| Expendable | 4,323 | 7,529 | | 7,529 | | |
| Equipment | | | | | | |
| Salaries (expatriate) | 8,458 | 8,458 | | 8,458 | | |
| Salaries (Nicaraguan) | 17,832 | 17,832 | | 17,832 | | |
| Indirect costs | 12,159 | 12,490 | | 12,490 | | |

(TABLE 7, cont.)

| Category | Grade 1 | | | Grade 2 | | |
|---|---|---|---|---|---|---|
| | 1975 | 1976 | 1977 | 1976 | 1977 | 1978 |
| ADMINISTRATION | | | | | | |
| STANFORD | | | | | | |
| Travel | 255 | | | 439 | | |
| Expendable | 497 | | | 685 | | |
| Computer | 8,056 | | | 8,369 | | |
| Salaries | 16,056 | | | 17,050 | | |
| Indirect costs | 13,930 | | | 14,864 | | |
| NICARAGUA | | | | | | |
| Travel | 1,262 | | | 948 | | |
| Expendable | 2,781 | | | 5,019 | | |
| Salaries (expatriate) | 26,113 | | | 26,113 | | |
| Salaries (Nicaraguan) | 24,718 | | | 24,718 | | |
| Indirect costs | 21,421 | | | 22,210 | | |
| PRODUCTION | | | | | | |
| STANFORD | | | | | | |
| Travel | 53 | | | 92 | | |
| Expendable | 103 | | | 685 | | |
| Computer | 1,678 | | | 1,743 | | |
| Salaries | 3,347 | | | 3,695 | | |
| Indirect costs | 2,902 | | | 3,097 | | |
| NICARAGUA | | | | | | |
| Travel | 9,470 | | | 7,110 | | |
| Expendable | 21,615 | | | 37,645 | | |
| Salaries (expatriate) | 65,495 | | | 57,873 | | |
| Salaries (Nicaraguan) | 80,974 | | | 80,974 | | |
| Recording costs | 13,366 | | | 13,366 | | |
| Indirect costs | 45,919 | | | 49,957 | | |
| TRANSMISSION | | 6,069 | | 6,069 | 6,069 | 12,138 |
| RECEPTION | | | | | | |
| NICARAGUA | | | | | | |
| Teacher training | 300 | 375 | | 396 | 396 | 25,908 |
| Teacher manuals | 400 | 800 | | 400 | 400 | 8,868 |
| Radio receivers | | 2,250 | 2,000 | | | |
| Radio batteries | | | 98 | 307 | 612 | 20,722 |
| Radio maintenance | | | 72 | | 1,120 | 5,857 |
| Tape recorders | | 2,000 | | | | |
| Tapes | | 5,100 | | | | |
| Student books | | 2,881 | 4,981 | | | |
| TOTAL COST | 370,969 | 530,145 | 183,303 | 431,352 | 128,894 | 73,523 |
| NUMBER OF STUDENTS | 0 | 800 | 2,000 | 2,000 | 3,000 | 64,005 |

## TABLE 8

Summary of Costs and Utilization for All Grade Levels
(in U.S. 1976 Dollars)

| Year | Grade 1 | | Grade 2 | | Grade 3 | | Grade 4 | | Grade 5 | | Grade 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Utilization | Costs | Utilization | Costs | Utilization | Costs | Utilization | Costs | Utilization | Costs | Utilization | Costs |
| 1974 | 0 | 370,969 | | | | | | | | | | |
| 1975 | 800 | 530,145 | | | | | | | | | | |
| 1976 | 2,000 | 183,803 | 2,000 | 431,352 | | | | | | | | |
| 1977 | 0 | 2,170 | 3,000 | 129,894 | 3,000 | 411,030 | | | | | | |
| 1978 | 0 | 135,000 | 64,005 | 73,523 | 48,556 | 179,953 | 3,000 | 411,030 | | | | |
| 1979 | 120,181 | 118,122 | 65,606 | 33,537 | 49,770 | 30,867 | 39,713 | 175,680 | 3,000 | 411,030 | | |
| 1980 | 123,186 | 35,937 | 67,246 | 34,561 | 51,014 | 31,329 | 40,706 | 34,284 | 31,408 | 163,187 | 3,000 | 411,030 |
| 1981 | 126,265 | 116,952 | 68,972 | 35,132 | 52,289 | 31,816 | 41,724 | 28,852 | 32,194 | 23,779 | 25,216 | 157,730 |
| 1982 | 129,422 | 52,103 | 70,650 | 104,187 | 53,597 | 32,300 | 42,766 | 29,251 | 32,998 | 24,071 | 25,846 | 21,657 |
| 1983 | 132,657 | 52,626 | 72,416 | 36,336 | 54,936 | 100,469 | 43,836 | 29,686 | 33,823 | 24,371 | 26,492 | 21,914 |
| 1984 | 135,974 | 186,425 | 74,227 | 36,920 | 59,310 | 33,319 | 44,932 | 97,041 | 34,669 | 24,664 | 27,155 | 22,151 |
| 1985 | 139,373 | 84,551 | 76,082 | 37,539 | 57,718 | 33,852 | 46,055 | 30,583 | 35,536 | 90,483 | 27,833 | 22,390 |
| 1986 | 142,858 | 57,180 | 77,985 | 38,201 | 59,160 | 34,401 | 47,206 | 31,041 | 36,424 | 25,297 | 28,529 | 87,507 |
| 1987 | 146,429 | 127,030 | 79,934 | 38,830 | 60,639 | 34,946 | 48,386 | 31,521 | 37,335 | 25,638 | 29,242 | 22,914 |
| 1988 | 150,090 | 61,295 | 81,932 | 99,521 | 62,155 | 35,735 | 49,596 | 32,000 | 38,268 | 25,977 | 29,973 | 23,184 |
| 1989 | 153,842 | 62,136 | 83,981 | 40,074 | 63,709 | 104,666 | 50,836 | 32,486 | 39,225 | 26,323 | 30,723 | 23,469 |
| 1990 | 157,688 | 196,178 | 86,080 | 40,886 | 65,302 | 36,706 | 52,107 | 100,714 | 40,206 | 26,661 | 31,491 | 23,748 |
| 1991 | 161,630 | 94,518 | 88,232 | 41,605 | 66,935 | 37,323 | 53,410 | 33,513 | 41,211 | 93,092 | 32,378 | 24,039 |
| 1992 | 165,671 | 67,460 | 90,438 | 42,339 | 68,608 | 37,956 | 54,745 | 34,066 | 42,241 | 27,403 | 33,085 | 89,658 |
| 1993 | 169,813 | 138,682 | 92,699 | 43,098 | 70,323 | 38,587 | 56,113 | 35,105 | 43,297 | 27,798 | 33,912 | 24,634 |
| 1994 | 174,058 | 72,168 | 95,017 | 114,573 | 72,081 | 39,259 | 57,516 | 35,170 | 44,379 | 28,174 | 34,760 | 24,956 |
| 1995 | 178,410 | 125,028 | 97,392 | 44,668 | 73,883 | 109,571 | 58,954 | 35,751 | 45,489 | 28,584 | 35,629 | 25,263 |
| 1996 | 182,870 | 207,485 | 99,827 | 45,479 | 75,730 | 40,623 | 60,069 | 104,947 | 46,626 | 28,992 | 36,520 | 25,604 |
| 1997 | 187,442 | 106,137 | 102,322 | 46,305 | 77,624 | 41,342 | 61,560 | 36,949 | 47,792 | 96,136 | 37,422 | 25,942 |
| 1998 | 192,128 | 79,314 | 104,881 | 47,163 | 79,564 | 42,067 | 63,099 | 37,558 | 48,987 | 29,849 | 38,369 | 92,128 |

TABLE 9

Average Costs per Student Hour for Grade 1,
Fast Implementation, Alkaline Batteries,
7.5% Interest Rate, in U.S. 1976 Dollars

| | 1974 | 1975 | 1976 | 1977 | 1978 |
|---|---|---|---|---|---|
| 1974 | | 1,161.17 | 413.43 | 414.14 | 454.98 |
| 1975 | | 662.68 | 263.53 | 264.24 | 305.09 |
| 1976 | | | 91.90 | 92.91 | 151.32 |
| 1977 | | | | | |

14. Teacher's guides are photocopied in the first year of production and printed in the implementation years.
15. Receivers are replaced every six years and 10% of them are repaired each year.
16. Batteries costing $1.50 have a life of 10 hours. Batteries costing $4.50 have a 50-hour life. From project experience we estimate that two-thirds of the country requires battery operation.

## 4. ANALYSIS OF DATA

In this section we analyze the cost implications of four separate decisions: rate of grade-level implementation, higher grade implementation, alternative program production, and alternative control of transmission facilities. Tables 10 through 18 contain the average cost per student calculated for each of the grades. Table 10 is for the first grade, Tables 11 through 14 are for four different assumptions regarding the second grade, and Tables 15 through 18 are for the third through the sixth grade, respectively. Each of these tables contains a large number of summary average-cost figures, $AC_{ij}$, the average cost per student from year $i$ (the row designations in each table) to year $j$ (the column designations in each table). If one looks at Table 10, one can see the pattern of declining costs as more students in later years are added to the project. For example, $AC_{1974,1978}$, the average cost per student during the period from 1974 to 1978, is $454.98, but for the longer time period until 1998, $AC_{1974,1998}$ is only $1.66. If we look at a period that excludes the early years when costs were high, the cost is even lower; for example, $AC_{1976,1998}$ is $.88.

### *Implementation Alternatives*

We have analyzed alternative implementation schedules for the second grade only for exemplary purposes. To calculate the values for Table 11, we assumed that the second-grade curriculum was implemented for the entire country in 1978. For the average costs calculated in Table 12 we assumed a slower implementation schedule of five approximately equal increments from 1978 to 1982, so the entire country would have second-grade programs in 1982 and thereafter. Therefore, the difference between the two implementation alternatives is revealed in the $AC_{ij}$ where $i$ = 1976 through 1981. As expected, the $AC_{ij}$ for these years are generally lower for the fast implementation than for the slow implementation. This fact indicates that, in terms of a summary cost measure, there is the expected greater reduction in average costs as the curriculum is more rapidly expanded to more students compared to the increase in average costs resulting from the additional reception cost of teacher's guides, teacher training, and radio batteries. As an example of the differences in $AC_{ij}$: $AC_{1976,1978}$ is $2.35 and $2.75 for the fast and slow implementations, respectively; the corresponding figures for $AC_{1976,1998}$ are $1.38 and $1.44. Similar results would also be expected for different implementation patterns in the other grades.

In terms of unit-cost patterns from the year of curriculum development, a more rapid implementation pattern is preferable. However, the decision on implementation rates will certainly be based on other factors, such as those related to the organization and management of implementation and to budgets. There may not be major organizational or management impediments to implementation, since grades other than the first require teacher training and distribution of guides only. This is a matter that would require further investigation and is not within the boundaries of cost analysis.

In analyzing budget factors that affect implementation patterns, we are concerned with cash flows. Therefore, we adjust budget estimates for future rates of inflation and analyze budgets in constant 1976 U.S. dollars. The four major elements of costs in expansion are radio receivers, radio batteries, teacher training, and teacher's guides. Two main decisions affecting the budget estimates are the number of grade levels being implemented and the power source used. We will separate the budgets for each of the grades and assume the use of alkaline batteries. (These batteries cost $1.65 per year per classroom and are needed in two-thirds of the classrooms; we analyze the cost implications of alternative power sources toward the end of this section.) We also assume that the number of radio receivers (which cost $50 each) is determined by the number of second-grade classrooms in 1978 and the number of first-grade classrooms in 1979 and beyond. Teacher's guides costing $2.14 each are assumed to be printed as needed. Teacher training costs $15 per teacher; for years 1979 and

### TABLE 10

### Average Costs per Student Hour for Grade 1, Fast Implementation, Alkaline Batteries, 7.5% Interest Rate, in U.S. 1976 Dollars

| | 1979 | 1980 | 1982 | 1984 | 1986 | 1988 | 1990 | 1992 | 1994 | 1996 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1974 | 13.99 | 7.39 | 4.20 | 3.19 | 2.61 | 2.28 | 2.09 | 1.92 | 1.80 | 1.74 | 1.66 |
| 1975 | 9.68 | 5.15 | 3.02 | 2.37 | 1.96 | 1.74 | 1.62 | 1.50 | 1.43 | 1.38 | 1.32 |
| 1976 | 4.00 | 2.19 | 1.46 | 1.27 | 1.10 | 1.02 | .99 | .94 | .91 | .91 | .88 |
| 1977 | 2.18 | 1.24 | .95 | .92 | .83 | .79 | .79 | .76 | .74 | .75 | .74 |
| 1978 | 2.16 | 1.23 | .95 | .92 | .82 | .79 | .79 | .76 | .74 | .75 | .73 |
| 1979 | .95 | .61 | .63 | .69 | .64 | .64 | .66 | .64 | .64 | .65 | .64 |
| 1980 | | .26 | .51 | .63 | .59 | .60 | .62 | .61 | .61 | .63 | .62 |
| 1982 | | | .37 | .68 | .60 | .61 | .64 | .62 | .61 | .64 | .63 |
| 1984 | | | | 1.34 | .78 | .72 | .74 | .69 | .67 | .70 | .68 |
| 1986 | | | | | .37 | .53 | .63 | .59 | .59 | .63 | .61 |
| 1988 | | | | | | .38 | .65 | .58 | .59 | .64 | .62 |
| 1990 | | | | | | | 1.22 | .73 | .68 | .74 | .69 |
| 1992 | | | | | | | | .38 | .52 | .66 | .61 |
| 1994 | | | | | | | | | .39 | .72 | .62 |
| 1996 | | | | | | | | | | 1.11 | .69 |
| 1998 | | | | | | | | | | | .39 |

## TABLE 11

Average Costs per Student for Grade 2, Fast Implementation, Alkaline Batteries, 7.5% Interest Rate, in U.S. 1976 Dollars

| | 1976 | 1977 | 1978 | 1979 | 1980 | 1982 | 1984 | 1986 | 1988 | 1990 | 1992 | 1994 | 1996 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 303.33 | 114.01 | 10.21 | 5.69 | 4.10 | 2.95 | 2.35 | 2.00 | 1.83 | 1.68 | 1.57 | 1.51 | 1.44 | 1.38 |
| 1977 | | 43.30 | 3.17 | 1.91 | 1.47 | 1.29 | 1.09 | .98 | .96 | .90 | .86 | .86 | .83 | .81 |
| 1978 | | | 1.15 | .84 | .73 | .83 | .74 | .70 | .72 | .69 | .67 | .68 | .67 | .65 |
| 1979 | | | | .51 | .51 | .74 | .66 | .63 | .66 | .64 | .62 | .64 | .63 | .61 |
| 1980 | | | | | .51 | .82 | .70 | .65 | .68 | .65 | .63 | .65 | .64 | .62 |
| 1982 | | | | | | 1.47 | .84 | .71 | .74 | .69 | .66 | .68 | .66 | .64 |
| 1984 | | | | | | | .50 | .49 | .62 | .59 | .56 | .60 | .59 | .57 |
| 1986 | | | | | | | | .49 | .72 | .63 | .59 | .63 | .61 | .59 |
| 1988 | | | | | | | | | 1.21 | .73 | .64 | .68 | .64 | .61 |
| 1990 | | | | | | | | | | .47 | .47 | .60 | .57 | .55 |
| 1992 | | | | | | | | | | | .47 | .70 | .61 | .57 |
| 1994 | | | | | | | | | | | | 1.21 | .72 | .62 |
| 1996 | | | | | | | | | | | | | .46 | .45 |
| 1998 | | | | | | | | | | | | | | .45 |

## TABLE 12

### Average Costs per Student for Grade 2, Slow Implementation, Alkaline Batteries, 7.5% Interest Rate, in U.S. 1976 Dollars

| | 1976 | 1977 | 1978 | 1979 | 1980 | 1982 | 1984 | 1986 | 1988 | 1990 | 1992 | 1994 | 1996 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 303.33 | 114.01 | 21.20 | 10.20 | 6.37 | 3.79 | 2.75 | 2.25 | 2.01 | 1.81 | 1.67 | 1.60 | 1.49 | 1.44 |
| 1977 | | 43.40 | 8.55 | 3.99 | 2.50 | 1.72 | 1.29 | 1.10 | 1.05 | .97 | .92 | .90 | .86 | .83 |
| 1978 | | | 1.63 | 1.07 | .87 | .97 | .79 | .73 | .75 | .71 | .68 | .69 | .67 | .65 |
| 1979 | | | | .74 | .67 | .90 | .75 | .69 | .72 | .69 | .65 | .67 | .66 | .64 |
| 1980 | | | | | .62 | .94 | .79 | .70 | .73 | .69 | .66 | .68 | .66 | .64 |
| 1982 | | | | | | 1.47 | .84 | .71 | .74 | .69 | .66 | .68 | .66 | .64 |
| 1984 | | | | | | | .50 | .49 | .62 | .59 | .56 | .60 | .59 | .57 |
| 1986 | | | | | | | | .49 | .72 | .63 | .59 | .63 | .61 | .59 |
| 1988 | | | | | | | | | 1.21 | .73 | .64 | .68 | .64 | .61 |
| 1990 | | | | | | | | | | .47 | .47 | .60 | .57 | .55 |
| 1992 | | | | | | | | | | | .47 | 70 | .61 | 57 |
| 1994 | | | | | | | | | | | | 1.21 | .72 | .62 |
| 1996 | | | | | | | | | | | | | .46 | .45 |
| 1998 | | | | | | | | | | | | | | .45 |

### TABLE 13

Average Costs per Student for Grade 2, Fast Implementation, Carbon-Zinc Batteries, 7.5% Interest Rate, in U.S. 1976 Dollars

| | 1976 | 1977 | 1978 | 1979 | 1980 | 1982 | 1984 | 1986 | 1988 | 1990 | 1992 | 1994 | 1996 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 303.43 | 116.07 | 10.57 | 5.99 | 4.36 | 3.20 | 2.59 | 2.24 | 2.07 | 1.91 | 1.80 | 1.74 | 1.64 | 1.51 |
| 1977 | | 46.77 | 3.54 | 2.20 | 1.17 | 1.54 | 1.33 | 1.22 | 1.19 | 1.14 | 1.09 | 1.09 | 1.06 | 1.04 |
| 1978 | | | 1.36 | 1.05 | .95 | 1.04 | .96 | .91 | .93 | .90 | .88 | .90 | .88 | .87 |
| 1979 | | | | .72 | .73 | .95 | .88 | .84 | .88 | .85 | .83 | .85 | .84 | .83 |
| 1980 | | | | | .73 | 1.03 | .91 | .86 | .90 | .87 | .85 | .86 | .85 | .84 |
| 1982 | | | | | | 1.69 | 1.05 | .92 | .96 | .91 | .88 | .89 | .87 | .86 |
| 1984 | | | | | | | .71 | .71 | .84 | .80 | .78 | .82 | .80 | .79 |
| 1986 | | | | | | | | .70 | .93 | .84 | .80 | .85 | .82 | .80 |
| 1988 | | | | | | | | | 1.43 | .95 | .85 | .90 | .86 | .83 |
| 1990 | | | | | | | | | | .69 | .69 | .82 | .78 | .76 |
| 1992 | | | | | | | | | | | .68 | .92 | .82 | .78 |
| 1994 | | | | | | | | | | | | 1.42 | .93 | .83 |
| 1996 | | | | | | | | | | | | | .67 | .67 |
| 1998 | | | | | | | | | | | | | | .66 |

### TABLE 14

### Average Costs per Student for Grade 2, Fast Implementation, Electricity, 7.5% Interest Rate, in U.S. 1976 Dollars

| | 1976 | 1977 | 1978 | 1979 | 1980 | 1982 | 1984 | 1986 | 1988 | 1990 | 1992 | 1994 | 1996 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 303.18 | 113.82 | 9.90 | 5.38 | 3.78 | 2.63 | 2.03 | 1.68 | 1.51 | 1.36 | 1.24 | 1.19 | 1.09 | .96 |
| 1977 | | 43.09 | 2.85 | 1.58 | 1.15 | .97 | .77 | .66 | .64 | .58 | .54 | .54 | .51 | .49 |
| 1978 | | | .82 | .51 | .41 | .50 | .42 | .37 | .39 | .37 | .34 | .36 | .34 | .33 |
| 1979 | | | | .19 | .19 | .41 | .34 | .30 | .34 | .31 | .30 | .31 | .30 | .29 |
| 1980 | | | | | .19 | .49 | .38 | .32 | .36 | .33 | .31 | .33 | .31 | .30 |
| 1982 | | | | | | 1.15 | .52 | .39 | .42 | .37 | .34 | .36 | .35 | .37 |
| 1984 | | | | | | | .17 | .17 | .30 | .26 | .24 | .28 | .26 | .25 |
| 1986 | | | | | | | | .17 | .39 | .31 | .26 | .31 | .28 | .26 |
| 1988 | | | | | | | | | .89 | .41 | .31 | .36 | .32 | .29 |
| 1990 | | | | | | | | | | .15 | .15 | .27 | .24 | .22 |
| 1992 | | | | | | | | | | | .14 | .37 | .28 | .24 |
| 1994 | | | | | | | | | | | | .88 | .39 | .30 |
| 1996 | | | | | | | | | | | | | .13 | .13 |
| 1998 | | | | | | | | | | | | | | .13 |

### TABLE 15

Average Costs per Student for Grade 3, Fast Implementation, Alkaline Batteries, 7.5% Interest Rate, in U.S. 1976 Dollars

| | 1977 | 1978 | 1979 | 1980 | 1982 | 1984 | 1986 | 1988 | 1990 | 1992 | 1994 | 1996 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 137.01 | 12.01 | 6.63 | 4.76 | 2.34 | 2.72 | 2.32 | 2.07 | 1.97 | 1.83 | 1.73 | 1.68 | 1.62 |
| 1978 | | 3.71 | 2.20 | 1.70 | 1.29 | 1.27 | 1.14 | 1.06 | 1.06 | 1.02 | .98 | .98 | .96 |
| 1979 | | | .62 | .62 | .61 | .79 | .75 | .72 | .77 | .75 | .73 | .75 | .74 |
| 1980 | | | | .61 | .61 | .83 | .77 | .73 | .79 | .76 | .74 | .76 | .75 |
| 1982 | | | | | .60 | .99 | .84 | .77 | .84 | .80 | .77 | .79 | .77 |
| 1984 | | | | | | .56 | .58 | .58 | .71 | .68 | .66 | .70 | .69 |
| 1986 | | | | | | | .58 | .58 | .78 | .72 | .69 | .74 | .71 |
| 1988 | | | | | | | | .57 | .93 | .79 | .73 | .78 | .75 |
| 1990 | | | | | | | | | .56 | .56 | .55 | .67 | .65 |
| 1992 | | | | | | | | | | .55 | .55 | .72 | .68 |
| 1994 | | | | | | | | | | | .54 | .85 | .73 |
| 1996 | | | | | | | | | | | | .54 | .53 |
| 1998 | | | | | | | | | | | | | .53 |

### TABLE 16

Average Costs per Student for Grade 4, Fast Implementation, Alkaline Batteries, 7.5% Interest Rate, in U.S. 1976 Dollars

| | 1978 | 1979 | 1980 | 1982 | 1984 | 1986 | 1988 | 1990 | 1992 | 1994 | 1996 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1978 | 137.01 | 14.39 | 8.03 | 4.62 | 3.66 | 3.02 | 2.63 | 2.46 | 2.26 | 2.12 | 2.05 | 1.97 |
| 1979 | | 4.42 | 2.68 | 1.73 | 1.63 | 1.42 | 1.29 | 1.29 | 1.22 | 1.17 | 1.17 | 1.13 |
| 1980 | | | .84 | .74 | .99 | .90 | .86 | .92 | .88 | .86 | .88 | .86 |
| 1982 | | | | .68 | 1.15 | .97 | .89 | .96 | .91 | .88 | .90 | .88 |
| 1984 | | | | | 2.16 | 1.18 | .99 | 1.06 | .98 | .92 | .95 | .92 |
| 1986 | | | | | | .66 | .65 | .88 | .82 | .78 | .84 | .81 |
| 1988 | | | | | | | .65 | 1.05 | .89 | .82 | .89 | .85 |
| 1990 | | | | | | | | 1.93 | 1.08 | .91 | .97 | .90 |
| 1992 | | | | | | | | | .62 | .62 | .82 | .76 |
| 1994 | | | | | | | | | | .61 | .97 | .83 |
| 1996 | | | | | | | | | | | 1.75 | 1.00 |
| 1998 | | | | | | | | | | | | .60 |

### TABLE 17

### Average Costs per Student for Grade 5, Fast Implementation, Alkaline Batteries, 7.5% Interest Rate, in U.S. 1976 Dollars

| | 1979 | 1980 | 1981 | 1982 | 1984 | 1986 | 1988 | 1990 | 1992 | 1994 | 1996 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1979 | 137.01 | 17.47 | 9.71 | 6.96 | 4.68 | 3.93 | 3.34 | 2.95 | 2.78 | 2.57 | 2.42 | 2.35 |
| 1980 | | 5.20 | 3.02 | 2.29 | 1.71 | 1.69 | 1.50 | 1.38 | 1.39 | 1.32 | 1.26 | 1.27 |
| 1981 | | | .74 | .73 | .73 | 1.00 | .93 | .89 | .97 | .93 | .90 | .94 |
| 1982 | | | | .73 | .72 | 1.06 | .97 | .91 | .99 | .95 | .92 | .95 |
| 1984 | | | | | .71 | 1.32 | 1.08 | .98 | 1.07 | 1.01 | .96 | 1.00 |
| 1986 | | | | | | .69 | .69 | .68 | .88 | .83 | .80 | .87 |
| 1988 | | | | | | | .68 | .67 | .97 | .89 | .84 | .91 |
| 1990 | | | | | | | | .66 | 1.19 | .99 | .89 | .98 |
| 1992 | | | | | | | | | .65 | .64 | .64 | .81 |
| 1994 | | | | | | | | | | .63 | .63 | .89 |
| 1996 | | | | | | | | | | | .62 | 1.08 |
| 1998 | | | | | | | | | | | | .61 |

### TABLE 18

Average Costs per Student for Grade 6, Fast Implementation, Alkaline Batteries, 7.5% Interest Rate, in U.S. 1976 Dollars

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1986 | 1988 | 1990 | 1992 | 1994 | 1996 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 137.01 | 21.08 | 11.79 | 8.47 | 6.75 | 5.32 | 4.36 | 3.79 | 3.52 | 3.23 | 3.01 | 2.90 |
| 1981 | | 6.26 | 3.61 | 2.73 | 2.28 | 2.17 | 1.87 | 1.69 | 1.69 | 1.59 | 1.51 | 1.51 |
| 1982 | | | .84 | .83 | .83 | 1.23 | 1.12 | 1.05 | 1.14 | 1.09 | 1.06 | 1.10 |
| 1983 | | | | .83 | .82 | 1.34 | 1.17 | 1.08 | 1.18 | 1.12 | 1.08 | 1.12 |
| 1984 | | | | | .82 | 1.53 | 1.25 | 1.13 | 1.23 | 1.16 | 1.11 | 1.15 |
| 1986 | | | | | | 3.07 | 1.58 | 1.27 | 1.38 | 1.26 | 1.18 | 1.22 |
| 1988 | | | | | | | .77 | .76 | 1.11 | 1.01 | .96 | 1.04 |
| 1990 | | | | | | | | .75 | 1.37 | 1.13 | 1.02 | 1.12 |
| 1992 | | | | | | | | | 2.17 | 1.42 | 1.15 | 1.25 |
| 1994 | | | | | | | | | | .72 | .71 | 1.01 |
| 1996 | | | | | | | | | | | .70 | 1.24 |
| 1998 | | | | | | | | | | | | 2.40 |

beyond this cost may be reduced by 35% for Grades 2 through 6 because many teachers teach more than one grade. The number of classrooms added is assumed for simplicity to be equal to the number of teachers added. Double sessions are not relevant to the analysis in that the same radio receiver may be used in the morning and afternoon. Therefore, one has the following formula for the implementation budget in any year $j$:

$$\text{Budget in year } j = 50T_{i,j-6} + 67.14T_{ij} + 11.89 \sum_{i=2}^{6} T_{ij} + 5.10 \sum_{i=1}^{6} \sum_{k=1976}^{j} T_{ik}$$

where $T_{ij}$ is the number of teachers added in grade $i$ in calendar year $j$.

The first term in the expression is the number of radios that are replaced. Radios are assumed to be replaced every six years. Radios are added to first-grade classrooms as the system expands. Assuming one teacher per classroom, we can calculate the current demand for radio replacements by considering the number of first-grade teachers who were added to the system six years in the past.

The second term in the equation is the budget expense for first-grade classrooms added in year $j$ including receivers, teacher training, and teacher's guides. (In 1978 this would be the number of second-grade classrooms.) The third term is the budget expense for classrooms added in Grades 2 through 6, consisting of teacher training and guides. (Obviously grades cannot be implemented until after the production year.) The fourth term is the cost of batteries (adjusted by the number of classrooms with no electricity). As batteries must be replaced for each grade level in all classrooms, regardless of the year a classroom was added to the system, we determine the total number of classrooms receiving instruction by adding classrooms from the initial year of implementation to year $j$. A substantial part of the budget expense is for battery replacement; if the schools continue to use carbon-zinc batteries, the annual battery costs will be 67% higher than our estimate, or $12.75 per year per classroom.

In Tables 13 and 14 we give $AC_{ij}$ for Grade 2 assuming rapid expansion and using carbon-zinc batteries and mainline electricity, respectively. The rather substantial effects on costs are clear. For example, $AC_{1976,1998}$ is $1.51, $1 38, and $.96 for carbon-zinc batteries, alkaline batteries, and mainline electricity, respectively; $AC_{1978,1998}$ (ignoring production and evaluation costs) would be $.87, $.65, and $.33. As the costs are so high for battery replacement, the implementation decision may be affected by the availability of electricity.

However, the more rural areas are less likely to have electricity, and availability would be a poor decision criterion. It is probable that the supply of electricity will be expanded throughout the country. However, we have assumed that two-thirds of the classrooms will not have access to electricity through 1998.

### *Production for Upper Grade Levels*

In Tables 15 through 18 we give $AC_{ij}$ for Grades 3 through 6, respectively. As expected, the costs increase for successively higher grade levels because of lower numbers of students. To compare grade levels one should use equivalent planning horizons. We will use 18 years, which means that costs are compared to a point just prior to the third program revision. We therefore have the following estimates:

| Grade level | Planning years | $AC_{ij}$ |
|---|---|---|
| 1 | $AC_{1974,1991}$ | $2.00 |
| 2 | $AC_{1976,1993}$ | 1.52 |
| 3 | $AC_{1977,1994}$ | 1.73 |
| 4 | $AC_{1978,1995}$ | 2.07 |
| 5 | $AC_{1979,1996}$ | 2.42 |
| 6 | $AC_{1980,1997}$ | 2.92 |

The costs given are average costs per student. Average costs per student lesson may be calculated by dividing by 170.

It is clear that costs rise considerably. The cost of producing a program for the sixth grade is nearly double that for the second grade. The costs of first grade are high because of the allocation of all start-up costs and all radio-receiver purchases to the first grade. Without these costs or with costs allocated by grade-level enrollment, the first grade would have considerably lower costs. If, in the future, dropout rates are reduced, the costs for the upper grade levels might be reduced. However, again, the decision on how to implement the curriculum should not be made on the basis of costs alone. The decision should include an estimation of the potential "value" of implementing the curriculum in the upper grade levels. As evaluation of mathematics learning continues over the next few years, more accurate estimates of some dimensions of this question may be possible.

### *Program Production Alternatives*

We have mentioned three possible alternatives for program production for the fifth and sixth grades. These alternatives are:

1. Expatriates remain for program production;
2. Nicaraguans replace expatriates and a master curriculum plan is produced at Stanford;
3. Nicaraguan financial support remains at 1976 levels (expatriates are not replaced) and a master curriculum plan is produced at Stanford.

It should be clear that Alternative 1 will be the most expensive and Alternative 3 the least. However, perhaps the most important component of any educational program is the curriculum. To choose properly among the alternatives we must assess the potential impact on educational effectiveness of the three alternatives.

Under the first alternative, curriculum development with a constantly revised master plan will be continued. This was the organization assumed in the calculation of $AC_{ij}$ for fifth and sixth grades (Tables 17 and 18, respectively). The costs for the first two years (program production in the first year and summative evaluation in the second year) are \$411,030 and \$163,187 for the fifth grade and \$411,030 and \$157,730 for the sixth grade.

Under the second alternative, all Stanford involvement in Nicaragua is eliminated except for a master curriculum plan produced at Stanford. The curriculum plan is still revised with an extensive testing program, but summative evaluation is eliminated. We assume that two additional Nicaraguans are hired at the top end of the Education Ministry salary schedule. The first- and second-year costs for the fifth grade (assuming \$330,000 at Stanford for the master curriculum plan) are \$220,341 and \$41,892, respectively. These costs for the sixth grade are \$220,341 and \$36,435.

For the third alternative, financial support is reduced to the \$69,020 currently paid by the Nicaraguan government and \$30,000 at Stanford for the fifth and sixth grade in the first year. It is clear that at this level of financial support the program effort would drop substantially and it would not be possible to continue the schedule of testing and curriculum modification. In Table 19 we summarize the costs for the first two years and selected $AC_{ij}$ for the fifth and sixth grades for each of the program production costs. As we can observe, first-year average costs ($AC_{1,1}$) drop by 80% from the most expensive alternative to the least. Average costs for an 18-year planning horizon ($AC_{1,18}$) drop by 50% from the most to the least expensive alternative.

### *Transmission Alternatives*

If transmission facilities in Nicaragua were rented, they would cost \$6,069 per year per grade level for single sessions and \$12,138 for double sessions. If all six grades were broadcast for the entire country, for six grade levels the cost would be \$72,828. The alternative is to

TABLE 19

Cost Comparisons for Program Production

| Alternatives | 1st year costs | 2nd year costs | $AC_{1,1}$[a] | $AC_{1,2}$ | $AC_{1,10}$ | $AC_{1,18}$ |
|---|---|---|---|---|---|---|
| | | | Grade 5 | | | |
| Alternative 1 | $411,030 | $163,187 | $137.01 | $17.47 | $3.34 | $2.42 |
| Alternative 2 | 220,341 | 41,892 | 73.44 | 7.79 | 1.82 | 1.53 |
| Alternative 3 | 99,020 | 41,892 | 33.00 | 4.02 | 1.23 | 1.18 |
| | | | Grade 6 | | | |
| Alternative 1 | 411,030 | 157,730 | 137.01 | 21.08 | 4.05 | 2.92 |
| Alternative 2 | 220,341 | 36,435 | 73.44 | 9.29 | 2.30 | 1.82 |
| Alternative 3 | 99,020 | 36,435 | 33.00 | 4.70 | 1.61 | 1.39 |

[a] Subscripts 1,1; 1,2; 1,10; and 1,18 are *calendar years* 1979, 1980, 1988, and 1996, respectively, for the fifth grade and 1980, 1981, 1990, and 1997, respectively, for the sixth grade.

construct transmission facilities for educational services. A 50-kilowatt transmitter, which would probably not cover the entire country, would cost approximately $1,200,000 for the transmitter, tower, building, and engineering.[10] A series of smaller transmitters might be less expensive.

A more detailed analysis accounting for topography and population dispersion would prove useful if this decision to construct transmission facilities were to be seriously considered.

If we assume a 20-year life for transmission facilities, the annualized capital cost (using a 7.5% interest rate) would be $117,710. To this must be added power, maintenance, and salary costs. Transmitters typically have an efficiency of 20%. A 50-kilowatt transmitter would require 250 kilowatts of power. For all six grades (in double session) electricity would be required for 1,020 hours during the year: a power requirement of 225,000 kilowatt-hours costing $25,500 at $.10 per kilowatt hour. Assuming an annual cost of $20,000 for the salary of a technician and for maintenance (a potentially low figure), the total annual cost would be $163,210 for owned transmission facilities. This is quite a bit higher than the $72,828 rental cost. The costs for ownership and rental would become equivalent at 2,968 hours of use compared with the 1,020 hours needed for all six grades.

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[10] This estimate was provided by Dr. James Janky, an electrical engineer with EDUTEL Communications and Development, Inc.

Alternatively, the transmission facility investment would have to diminish to $278,595 to make the annual cost equivalent for 1,020 hours of broadcasting.

On the basis of costs it would not be wise to consider purchase of transmission facilities. Further analysis would be useful if it seemed likely that transmission facilities could not be rented or if there were thought to be potential societal benefits from a government-owned network.

### *Cost Implications of Alternatives*

We again emphasize that any policy recommendations should be based on an evaluation of potential impact on the value of the programs in addition to the costs. A summary of the cost implications of the alternatives examined is given below.

**Rate of implementation.** Lowest costs are obtained through the most rapid implementation. If there are no serious budget, pedagogical, or social constraints, the program for any grade level should be fully implemented in the year following program production. (Substantial savings will probably be realized through the use of alkaline batteries in those areas not served by mainline electricity.)

**Implementation to upper grade levels.** Average costs for an 18-year planning horizon are $2.00, $1.52, $1.73, $2.07, $2.42, and $2.92 for the first through sixth grades, respectively. Higher costs in the upper grade levels are due to substantially lower enrollment levels. Implementation will, of course, depend on the perceived value of the reform at each grade level relative to the costs.

**Alternative program production.** The cost of implementation to the fifth and sixth grade can be reduced substantially through a reduction of utilization of expatriates. If, for example, summative evaluation is eliminated and expatriates are replaced with Nicaraguans for program production, the average costs for the 18-year planning horizon will drop from $2.42 to $1.53 for the fifth grade and $2.92 to $1.82 for the sixth grade.

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## *Chapter 10*

# NICARAGUAN STANDARDIZATION OF THE STANFORD MENTAL ARITHMETIC TEST

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THE CURRICULUM of the Radio Mathematics Project includes a sizable component of mental arithmetic. It is important to evaluate this aspect of the project by assessing the resulting ability of students to perform mental arithmetic. In contrast to traditional arithmetic exercises, mental arithmetic exercises are presented orally with no supporting visual stimuli; students may respond either orally or in writing. Because no evaluation instrument measuring mental arithmetic skills was found, the project staff at Stanford University undertook in 1973 to develop such an instrument. The result was the *Stanford Mental Arithmetic Test (SMAT)*.

## 1. THE STANFORD MENTAL ARITHMETIC TEST (SMAT)

Six levels of the SMAT, appropriate for Grades 1 through 6 in the United States, were developed by the author (Olshen, 1975). The tests for Grades 1 through 3 cover number concepts, addition, and subtraction; those for Grades 4 through 6 cover multiplication, division, fractions, and measurement as well. Each test includes items ranging in difficulty from those that most students in the appropriate grade level can answer correctly to those that few can answer correctly. The items are arranged in ascending order of difficulty (as determined by pilot testing in the United States). The test is administered using a prerecorded tape. Six seconds are allotted between items for the students to respond on prepared answer sheets. Items are identified by letters of the alphabet.

### *Development of the Nicaraguan Version of the SMAT*

The test standardized in Nicaragua was Form A of the Primary-I level of the SMAT, appropriate for U.S. Grade 1. This test includes an introduction with five sample exercises and 100 test items (52 addition, 33 subtraction, and 15 number concepts).

The test was translated into Spanish by a Nicaraguan staff member and administered to a class of second-grade students in a rural school in the Department of Masaya. These students had difficulty finding the correct place on the answer sheet to record their responses and many did not understand the instructions.

The instructions were rewritten, and the taped introduction was expanded to include more practice in finding each item's lettered identifier on the answer sheet. In addition, a 10-minute lesson was written that taught the five letters used as identifiers. This minilesson was pilot-tested with first- and second-grade students in two rural schools in the Department of Masaya and was found to be adequate. As another aid to students, the number of sample items on the pilot test was increased from 5 to 10, giving practice on all the item identifiers. The administrators felt that the minilesson helped the students respond appropriately to the test and it was incorporated into the taped introduction.

A final revision of the test dealt with the problem of translating the exercises into Spanish. In developing the U.S. SMAT, the spoken English expression of each item was determined from its written mathematical form. The same procedure was used to produce the Spanish version. We strove to find the expression that would be most easily understood by the children. However, there was some disagreement among Nicaraguan staff members on the wording of the questions. Therefore, we gave the symbolic form to four Nicaraguan experts (three former elementary teachers and one professor of education at the National University), asking them to write the Spanish oral form. Four distinct translations resulted for some exercises. The differences were resolved at a meeting of the Nicaraguans. The oral expressions were subsequently changed slightly so that exercises in similar formats were expressed consistently across arithmetic operations. Examples of the oral and corresponding symbolic formats are presented at the end of this chapter in Appendix A. Appendices B and C contain the U.S. and Nicaraguan tests, respectively.

The final Nicaraguan version of the SMAT parallels the U.S. version. Each of the 100 oral exercises consists of the lettered item identifier, the question, and a 6-second pause. The test is arranged into 10 10-item parts with a 90-second break after the fourth and the eighth parts. As described above, the introduction to the Nicaraguan version is longer and includes 10 sample exercises instead of 5.

### *The Norming Population*

A sampling plan was developed to norm the Nicaraguan SMAT using public-school children in Grades 1 through 6 in the Department of Masaya. We later learned from the Office of Research in the Ministry of Public Education that the phrasing of mathematics problems as well as other language usage varies in different parts of the country, particularly on the western coast. Therefore, the norms established for students in Masaya might not be appropriate for the entire country. All six grades were included in the testing program.

The public schools in the Department of Masaya were divided into regional strata: urban, rural, and municipal. The schools we defined as urban are in the two largest towns, Masaya and Masatepe. The municipal schools are those in all other towns classified by the Ministry of Education as urban. The remaining schools are considered rural. (This three-way stratification is discussed in chap. 3.)

In the fall of 1975, 1,096 Nicaraguan students in Grades 1 through 6 took the test. Approximately 150 students were sampled from each grade, taking students from each regional stratum proportionately within a grade. In the urban and municipal schools, each grade was sampled individually. Because of the small number of children in many rural grades, the rural students were sampled two grades at a time.

The U.S. standardization of the SMAT (Olshen, 1975) took place in the California public schools in 1974. The grade placement of the students was .8 on the U.S. school-year calendar at the time of testing. The kindergarten and first-grade students were administered level I, the second-grade students level II, and the third-, fourth-, and fifth-grade students level III of the SMAT. As the test level increases, the items become more difficult. However, all three levels cover the same concepts—addition, subtraction, and number concepts. For each grade, the proportion correct on each item from level I was estimated using the method of Olshen (1975). This method first determines the relation between proportion correct for Grade 1 and for another grade using items taken by both and then it estimates the proportion correct on each item for the other grade from the proportion for Grade 1. The correlations between concepts for Grades 2 through 5 for the U.S. population discussed below represent the correlations between the sets of items on the upper-level tests, not the correlations between the sets of items on level I.

## 2. TEST RESULTS

Nicaraguan test results were compared to the U.S. results and were analyzed to determine the relative performance of the Nicaraguan and U.S. populations on the SMAT, the adequacy of the SMAT for the Nicaraguan population, the relation between arithmetic concepts within a grade, and the patterns of scores across ages and grades. Grade- and age-equivalent score conversions and percentile ranks were developed for the Nicaraguan population.

The median score on the test for students at a given grade level was taken to be the grade-equivalent score for that level at the time the test was given. For example, the median score of students tested at grade level 4.6 was 67. Therefore, 67 is the grade-equivalent score for grade level 4.6. A function[1] relating the median score (dependent variable) to grade level (independent variable) was found. The grade-equivalent score for each intermediate grade level not sampled was determined from this function.

Age equivalents were computed similarly, with age as the independent variable and median score as the dependent variable. Grade equivalents, age equivalents, and percentile rankings corresponding to each raw score are given in Appendix D, which also includes the instructions for administering the test and analyzing the results.

### *Means, Standard Deviations, and Medians*

**By concept.** The percent correct for individual test items is presented in Appendix E for both Nicaraguan and U.S. Grades 1 and 5. An informal examination of these test scores indicates that the Nicaraguan students perform slightly below the level of the U.S. students on all three concepts included in this measure of mental arithmetic ability.

Table 1 summarizes Appendix E, dividing each major concept into three subconcepts or formats. First graders in the United States performed better than their Nicaraguan counterparts on all subconcepts included under the number-concepts category; 70%, 71.4%, and 55.4% of the U.S. students responded correctly to the "write" (e.g., "Write the number *n*."), "size" (e.g., "Which is bigger, *n* or *m*?"), and "order" (e.g., "What comes between $n-1$ and $n + 1$?") items, respectively, compared with 43%, 30.4%, and 13.8% for the Nicaraguan students. Upon examining the individual test-item scores in

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[1] The function is of the form $Y = A + BX^C$ where $Y$ is the score and $X$ the grade level. The constants $A$, $B$, and $C$ are least squares estimates determined from the six pairs of scores and grade levels. The resulting functions are:

Number concepts $Y = -6776.0 + 6776.0X^{.00118}$ (6 pts.)
$Y = -497.3 + 502.2X^{.01}$ (5 pts.)
Addition $Y = -212.3 + 201.3X^{.15}$
Subtraction $Y = -15220.0 + 15220.0X^{.0011}$

### TABLE 1

### First- and Fifth-grade Performance on Concepts

| Concept/subconcept | Percent correct | | | |
|---|---|---|---|---|
| | Grade 1 | | Grade 5 | |
| | Nicaragua | U.S. | Nicaragua | U.S. |
| Number concepts | | | | |
| "write" | 43.0 | 70.0 | 89.6 | 99.2 |
| "size" | 30.4 | 71.4 | 93.0 | 99.2 |
| "order" | 13.8 | 55.4 | 82.4 | 96.4 |
| Addition | | | | |
| $n + m = \_\_$ | 17.3 | 26.8 | 80.2 | 89.1 |
| $n + \_\_ = m$ | 6.5 | 21.9 | 62.6 | 83.2 |
| $\_\_ + n = m$ | 9.0 | 23.6 | 70.6 | 89.1 |
| Subtraction | | | | |
| $n - m = \_\_$ | 18.0 | 26.7 | 84.4 | 90.5 |
| $n - \_\_ = m$ | 10.3 | 17.1 | 70.0 | 80.4 |
| $\_\_ - n = m$ | 7.3 | 4.3 | 14.3 | 58.8 |

Appendix E, we note that both first-grade populations had particular difficulty with item 48 ("Write the number 573.") indicating that neither group has had much experience with such large numbers at this early stage of their schooling. Support for this conclusion is provided by their poor performance on items with three-digit numbers in the other concept categories (e.g., items 67, 88, 94, 97, and 100).

As indicated in Table 1, the difference between Nicaraguan and U.S. performance is smaller at the fifth- than at the first-grade level. Though the U.S. fifth graders scored slightly higher than the Nicaraguan students on number concepts, 99.2%, 99.2%, and 96.4% responded correctly to the "write," "size," and "order" items, respectively, compared with 89.6%, 93%, and 82.4% for the Nicaraguan students. The decreasing difference may be due to a ceiling effect, with both fifth-grade groups scoring close to 100%. Note that the difficulty exhibited by both the Nicaraguan and the U.S. first graders with "order" items relative to the other two subconcepts does not occur in the fifth grade.

In general, U.S. first graders performed better than Nicaraguan first graders on all oral addition formats; 26.8%, 21.9%, and 23.6% of the U.S. students responded correctly to items of the form $n + m = \_\_$

(i.e., "What is $n$ plus $m$?"), $n + \_\_ = m$ (i.e., "$n$ plus what equals $m$?"), and $\_\_ + n = m$ (i.e., "What plus $n$ equals $m$?"), respectively, compared with 17.3%, 6.5%, and 9.0% for the Nicaraguan students.

Items of the form $n \pm m = \_\_$ are referred to as *canonical*, those of the other two forms, $n \pm \_\_ = m$ and $\_\_ \pm n = m$, as *noncanonical*. Students typically have more difficulty with exercises in noncanonical format (see Suppes & Morningstar, 1972, p. 60). On six items (items 57, 60, 73, 88, 90, and 91) Nicaraguan performance surpassed that of U.S. students. These items all appear on the second half of the test. Of these items, two are of the noncanonical form $n + \_\_ = m$; two of the remainder are canonical and two are in canonical form with three addends. The results suggest that U.S. students may be more proficient than Nicaraguans on items they know fairly well but not on those they do not know well. Both U.S. and Nicaraguan students performed more poorly on addition items than on number-concept items in the first grade. Although both groups scored low on noncanonical items, Nicaraguan first graders had more difficulty with these items relative to the canonical items than did U.S. students.

Although both groups had improved nearly 60 percentage points by the fifth grade, U.S. performance was still higher: 89.1%, 83.2%, and 89.1% of the U.S. students and 80.2%, 62.6%, and 70.6% of the Nicaraguan students responded correctly to each of the addition formats. Nicaraguans scored higher only on item 4, and the difference was less than one percentage point. The difference in both populations between performance on addition and on number concepts remains intact, although to a lesser degree, again likely due to the ceiling effect. Recall the items were approximately ordered by difficulty. Examining Appendix E, we note that in both the first and fifth grades the proportion correct decreases with higher numbered items. Although performance on addition improves across all items in the fifth grade for both populations, the greatest improvement is exhibited in the later items.

Generally, the U.S. first graders performed better than the Nicaraguan first graders on problems in two of the three oral subtraction formats; 26.7%, 17.1%, and 4.3% of the U.S. students responded correctly to problems of the form $n - m = \_\_$ (i.e., "What is $n$ take away $m$?"), $n - \_\_ = m$ (i.e., "$n$ take away what equals $m$?"), and $\_\_ - n = m$ (i.e., "What take away $n$ equals $m$?"), respectively, compared with 18.0%, 10.3%, and 7.3% for the Nicaraguan students. Interestingly, the U.S. students scored higher on the first 19 items but, of the last 14, they scored higher on only 3 items. Thus, the Nicaraguan students are more proficient on the more difficult items, whereas the U.S. students are more proficient on the easier ones. Many of the these latter items were of the form $\_ - n = m$. On the whole, Nicaraguan first graders performed better on subtraction items than on addition items. Finally, both U.S. and Nicaraguan first graders performed better on subtraction items in which "what" is heard after the operator ($n - \_ = m$) than on those in which it precedes the operator ($\_ - n = m$).

Suppes and Morningstar (1972) examined the effect of the position of the blank in written arithmetic exercises for students using computer-assisted instruction. They write that

> noncanonical subtraction problems are probably harder than noncanonical addition problems. . . . (Noncanonical problems) with blanks to the left of the operation seem harder for students than blanks to the right of the operation with this effect being greater for subtraction problems than for addition problems. (p. 72)

Findings on the oral SMAT for the U.S. first graders generally support Suppes and Morningstar's conclusions except for the difference between the two noncanonical addition exercises. Similarly, Nicaraguan first graders performed in the opposite fashion with respect to the relative difficulty of the two noncanonical addition exercises. Nicaraguan performance on the two types of noncanonical subtraction problems is not as dissimilar as U.S. performance, only weakly supporting their conclusion for the Nicaraguan population.

An improvement in performance on subtraction problems in all formats occurred by the fifth grade in both populations; 90.5%, 80.4%, and 58.8% of the U.S. students responded correctly to problems in each of the formats, compared with 84.4%, 70.0%, and 14.3% of the Nicaraguan students. Performance on noncanonical subtraction in both populations is considerably lower than performance on noncanonical addition, but performance on canonical subtraction is higher. By the fifth grade both populations find noncanonical items with the blank ("what") to the left extremely difficult, a finding consistent with Suppes and Morningstar (1972). Note how little the Nicaraguan fifth graders have improved their performance on these items in comparison with their performance on the others.

**By grade.** As may be seen in Table 2, in the Nicaraguan population mean score increases with grade for all concepts. As with most measures of academic performance, however, the increment from grade to grade decreases as the grade level increases.

The most desirable difficulty level of a free-response test is one in which the mean is 50% correct, so that the scores can spread around either side of the mean. If the mean is too close to either of the extremes (none correct or all correct), a floor or ceiling effect occurs and the test (or subtest) is less able to differentiate between students

TABLE 2

Mean and Proportion Correct on Subtests by Grade for Nicaraguan Students

| Grade | Number concepts (Max. = 15) | | Addition (Max. = 52) | | Subtraction (Max. = 33) | | Total test (Max. = 100) | |
|---|---|---|---|---|---|---|---|---|
| | Mean | % correct | Mean | % correct | Mean | % correct | Mean | % correct |
| 1 | 4.43 | 29.5 | 6.55 | 12.6 | 4.71 | 14.3 | 15.68 | 15.7 |
| 2 | 9.63 | 64.2 | 18.10 | 34.8 | 12.76 | 38.7 | 40.49 | 40.5 |
| 3 | 11.25 | 75.0 | 25.85 | 49.7 | 16.37 | 49.6 | 53.47 | 53.5 |
| 4 | 12.98 | 86.5 | 32.87 | 63.2 | 20.03 | 60.7 | 65.88 | 65.9 |
| 5 | 13.33 | 88.9 | 37.75 | 72.6 | 22.23 | 67.4 | 73.31 | 73.3 |
| 6 | 14.10 | 94.0 | 43.79 | 84.2 | 24.70 | 74.8 | 82.58 | 82.6 |

and is thus a less sensitive measure of ability to perform mental arithmetic. The largest possible dispersion of number-concepts scores is at the second-grade level with a mean percent correct of 64.2. The means for Grade 3 (in percent correct) on the addition subtest (49.7) and the subtraction subtest (49.6) are both almost exactly at 50%. Thus the difficulty level of these two subtests is most appropriate for Grade 3. Because these two subtests comprise 85% of the test, the difficulty level of the total test is also most appropriate for Grade 3.

The median score, shown in Table 3 together with its corresponding percent correct, increases with an increase in grade level. This relation is shown graphically in Figures 1 through 4. As with the mean, the median most closely approximates 50% correct for number

TABLE 3

Median and Proportion Correct on Subtests by Grade for Nicaraguan Students

| Grade | Number concepts (Max. = 15) | | Addition (Max. = 52) | | Subtraction (Max. = 33) | | Total test (Max. = 100) | |
|---|---|---|---|---|---|---|---|---|
| | Median | % correct | Median | % correct | Median | % correct | Median | % correct |
| 1 | 2.80 | 18.7 | 3.33 | 6.4 | 1.66 | 5.0 | 9.50 | 9.5 |
| 2 | 9.50 | 63.3 | 17.00 | 32.7 | 13.00 | 39.4 | 39.67 | 39.7 |
| 3 | 11.67 | 77.8 | 25.00 | 48.1 | 17.50 | 53.0 | 56.00 | 56.0 |
| 4 | 13.00 | 86.7 | 33.50 | 64.4 | 21.00 | 63.6 | 67.00 | 67.0 |
| 5 | 13.66 | 91.1 | 40.00 | 76.9 | 23.00 | 69.7 | 77.50 | 77.5 |
| 6 | 14.20 | 94.7 | 45.50 | 87.5 | 25.50 | 77.3 | 85.50 | 85.5 |

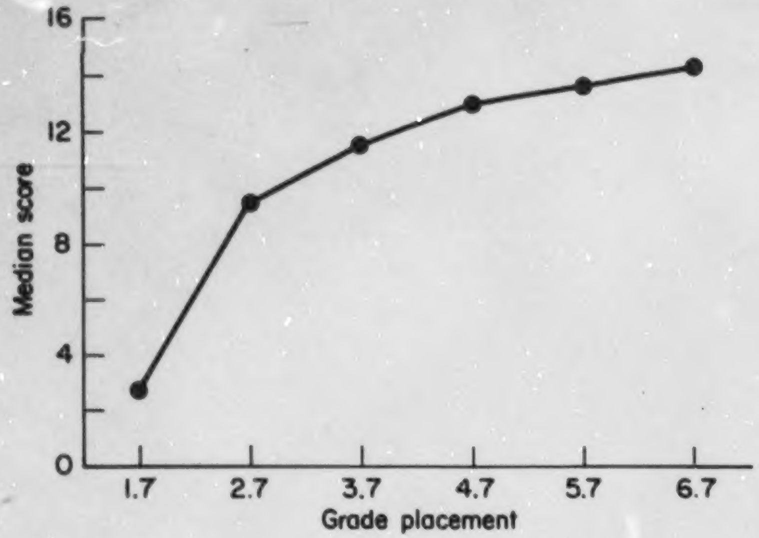

FIGURE 1. Number concepts medians by grade placement.

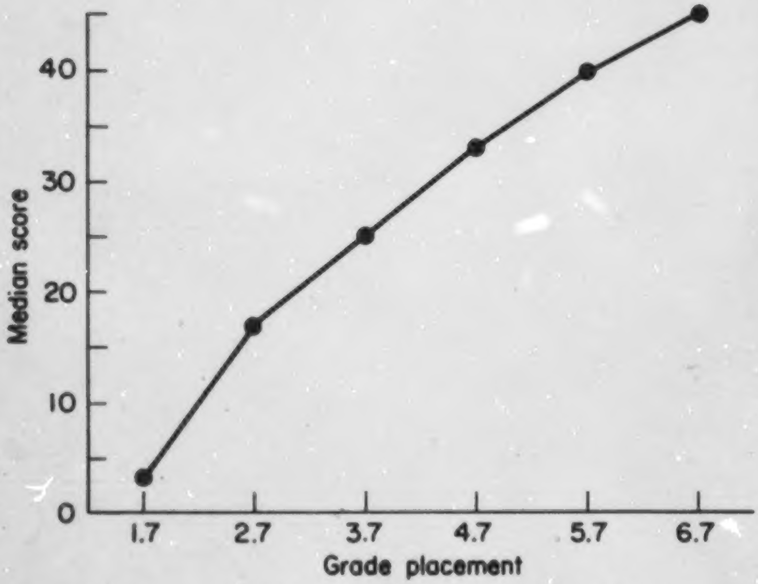

FIGURE 2. Addition medians by grade placement.

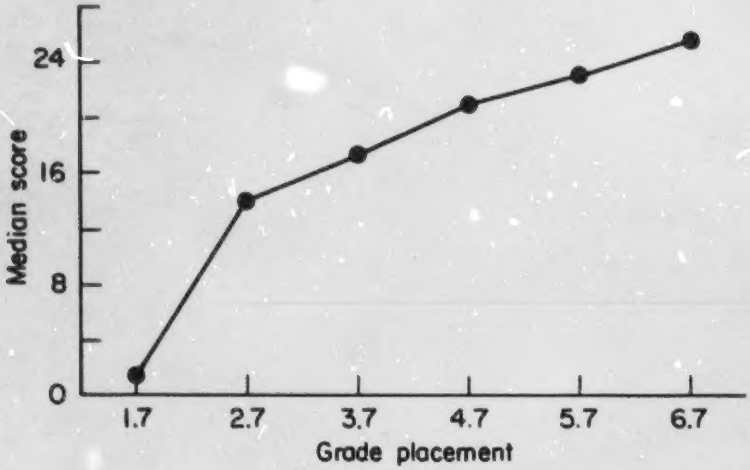

FIGURE 3. Subtraction medians by grade placement.

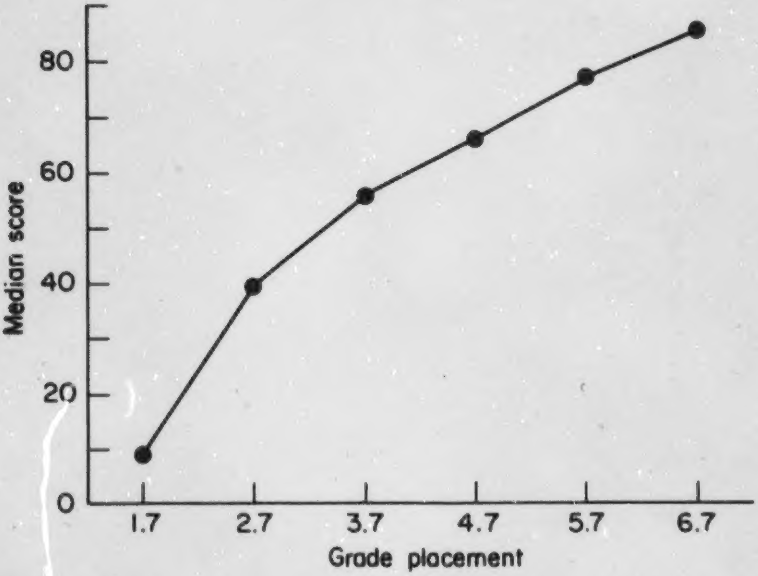

FIGURE 4. Total score medians by grade placement.

TABLE 4

Mean, Standard Deviation, and Median of Total Test Scores by Age for Nicaraguan Students

| Age | *SD* | Mean | Median | *N* |
|---|---|---|---|---|
| 6 | 19.01 | 22.50 | 22.50 | 14 |
| 7 | 15.85 | 14.73 | 8.50 | 70 |
| 8 | 23.66 | 25.77 | 16.67 | 102 |
| 9 | 23.54 | 39.19 | 39.00 | 145 |
| 10 | 25.67 | 46.01 | 38.50 | 162 |
| 11 | 26.26 | 55.17 | 60.00 | 149 |
| 12 | 22.86 | 62.63 | 68.00 | 140 |
| 13 | 24.30 | 66.31 | 73.00 | 120 |
| 14 | 24.35 | 67.22 | 71.50 | 83 |
| 15 | 20.86 | 71.64 | 79.00 | 63 |
| 16 | 17.24 | 75.65 | 81.00 | 23 |
| 17 | 18.11 | 77.11 | 83.00 | 9 |
| 18 | 9.78 | 80.20 | 77.00 | 5 |

concepts in Grade 2, and for addition, subtraction, and total score in Grade 3.

**By age.** Means, standard deviations, and medians for the total score for students by age are presented in Table 4. Both the means and the medians increase monotonically with increasing age (Fig. 5), except at age 6 where the mean and median are substantially higher than at age 7. There were only 14 6-year-olds in the sample—undoubtedly not representative of the entire age cohort. The estimates at ages 17 and 18 are also based on very small samples and are included only for completeness. Because of their small sizes these age-group samples—6, 17, and 18—are not included in any further analyses.

**By age within grade.** Table 5 presents the mean performance levels by age within grade for the Nicaraguan students. The official age for entering Grade 1 is 7 years. Such a student, if he did not repeat, would be 12 years old by Grade 6. However, only about 25% of the urban children, and only 3% of the rural children, progress directly from Grade 1 to Grade 6 in six years (Academy for Educational Development, 1975). From the columns of Table 5 it is evident that within each grade there is a slight increase in score with age for the earlier grades, but essentially no relation between age and score for the later grades. From the rows of the table, however, we see that within-age test scores increase with grade level. Thus, the higher the

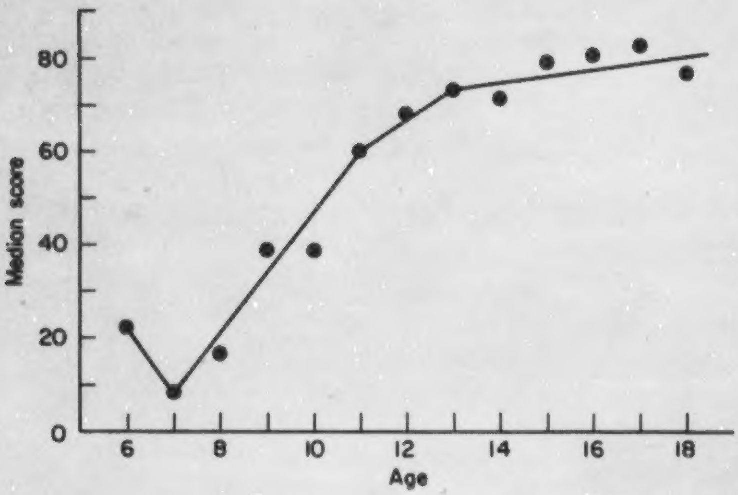

FIGURE 5. Median total score by age.

grade level obtained by a student of a given age, the greater his mental-arithmetic achievement level. It seems clear that, although performance levels depend on both age and grade, schooling has a stronger effect than age. (This kind of relation is difficult to observe in U.S. schools where the age range within each grade level is quite narrow.)

TABLE 5

Mean Total Scores by Age Within Grade for Nicaraguan Students

| Age | Grade | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 7 | 9.72 | 32.58 | | | | |
| 8 | 8.96 | 36.69 | 58.09 | 39.67 | | |
| 9 | 16.53 | 38.20 | 50.26 | 66.54 | 60.50 | |
| 10 | 25.69 | 42.44 | 42.88 | 70.39 | 79.44 | |
| 11 | 20.21 | 43.86 | 63.03 | 67.58 | 77.00 | 79.75 |
| 12 | 28.78 | 47.70 | 63.00 | 62.90 | 70.33 | 84.47 |
| 13 | 23.86 | 44.50 | 52.07 | 66.13 | 73.77 | 85.41 |
| 14 | | 42.71 | 52.86 | 67.00 | 69.68 | 84.88 |
| 15 | | 25.67 | 60.70 | 71.25 | 76.74 | 83.20 |
| 16 | | 40.67 | | | 80.75 | 82.64 |

*Note.* Means are shown only for cells of $n > 1$.

TABLE 6

Correlation Between Item Position and Rank of Proportion Correct for Nicaraguan Students

| Grade | *r* | *N* |
|---|---|---|
| 1 | .637 | 231 |
| 2 | .649 | 243 |
| 3 | .667 | 184 |
| 4 | .703 | 154 |
| 5 | .725 | 158 |
| 6 | .791 | 126 |

### *Item Sequence*

To assess whether the test items remained in ascending order of difficulty for the Nicaraguan population, the correlation between an item's position on the test and its rank by proportion correct was computed. The correlation coefficients, shown in Table 6, range from .64 to .79 and increase as the grade level increases. This indicates that, although the ordering is more appropriate for the upper grades, it is also adequate for the lower grades.

The correlation between item order and rank by proportion correct for the U.S. student population is shown in Table 7. A comparison of these correlations with those of Table 6 finds them uniformly higher for the U.S. students. As expected, although the item sequence is adequate for the Nicaraguan population, it is more appropriate for the U.S. population. More specifically, the correlations for the Nicaraguan population increase with grade level for all six grades, whereas the correlations for the U.S. population peak at Grade 2, decreasing consistently for the upper grades. Thus, the item sequence

TABLE 7

Correlation Between Item Position and Rank of Proportion Correct for U.S. Students

| Grade | *r* | *N* |
|---|---|---|
| K | .777 | 133 |
| 1 | .913 | 143 |
| 2 | .917 | 121 |
| 3 | .912 | 154 |
| 4 | .897 | 127 |
| 5 | .887 | 131 |

is best for the upper grades in Nicaragua and for the lower grades (except kindergarten) in the United States.

### *Comparison of Item Performance Between Grades*

Correlation coefficients were also used to assess the relation between proportion correct in pairs of grades. Table 8 presents the resulting correlation matrix for the Nicaraguan population. The strength of the relation generally decreases as the spread between grades increases. The entries just above the main diagonal are the correlations for pairs of grades differing by one year and range from .45 to .96. The three entries in the upper right-hand corner are the correlations for pairs of grades differing by four or five years. The range, from .44 to .67, is somewhat lower.

The upper half of Table 9 presents the linear correlation between proportion correct among grades for U.S. students. Like the Nicaraguan population, the U.S. correlations between proportion correct among grades decrease as the grade difference increases. However, unlike the Nicaraguan population, in which lower correlations were found for Grades 4 and 5 (Table 8), there are no deviations from this trend. The lower half of Table 9 presents correlations between proportion correct among Nicaraguan and U.S. grades. For the lower grades, high correlations are found between the lowest U.S. school grade (K) and the lowest Nicaraguan school grade (1), between U.S. Grade 1 and both Nicaraguan Grades 1 and 2, and between U.S. Grade 2 and both Nicaraguan Grades 2 and 3. Correlations with U.S. Grades 3 through 5 increase as the Nicaraguan grade level increases, except for Nicaraguan Grades 4 and 5. The results for these two grades do not fit the expected pattern. From these data it appears that the relative difficulty of items is most similar for approximately equal grade levels. Also, excluding Grades 4 and 5, the correlation coefficients below the diagonal are slightly higher than those above

TABLE 8

Linear Correlations Between Proportion Correct Among Grades for Nicaraguan Students

| Grade | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1.00 | .86 | .78 | .48 | .44 | .47 |
| 2 | | 1.00 | .96 | .52 | .48 | .67 |
| 3 | | | 1.00 | .52 | .48 | .79 |
| 4 | | | | 1.00 | .45 | .86 |
| 5 | | | | | 1.00 | .94 |
| 6 | | | | | | 1.00 |

TABLE 9

Linear Correlations Between Proportion Correct Among Grades for U.S. and Nicaraguan Students

| | | United States | | | | | |
|---|---|---|---|---|---|---|---|
| | Grade | K | 1 | 2 | 3 | 4 | 5 |
| United States | K | 1.00 | .66 | .44 | .36 | .30 | .26 |
| | 1 | | 1.00 | .88 | .81 | .72 | .66 |
| | 2 | | | 1.00 | .94 | .87 | .82 |
| | 3 | | | | 1.00 | .96 | .93 |
| | 4 | | | | | 1.00 | .99 |
| | 5 | | | | | | 1.00 |
| Nicaragua | 1 | .74 | .74 | .67 | .59 | .54 | .50 |
| | 2 | .47 | .73 | .77 | .71 | .68 | .64 |
| | 3 | .41 | .70 | .78 | .77 | .75 | .73 |
| | 4 | .34 | .62 | .68 | .66 | .63 | .60 |
| | 5 | .29 | .56 | .63 | .62 | .60 | .57 |
| | 6 | .23 | .56 | .71 | .78 | .81 | .83 |

the diagonal for comparable grades. This indicates that the relative difficulty of the test for the higher Nicaraguan grades most closely approximates its relative difficulty for the lower U.S. grades. One might conclude from this that the Nicaraguan students may be learning at a slightly slower pace than the American students.

Because the relation between proportion correct in two different grades may not be linear (Olshen, 1975), the correlations between items *ranked* by proportion correct in each grade were found. These are shown in Table 10 for the Nicaraguan population. The result of removing the nonlinearity is a range of rank correlations between .55 and .97 for adjacent pairs of grades and between .61 and .87 for those

TABLE 10

Rank Correlations Between Proportion Correct Among Grades for Nicaraguan Students

| Grade | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1.00 | .91 | .89 | .59 | .61 | .80 |
| 2 | | 1.00 | .97 | .57 | .61 | .87 |
| 3 | | | 1.00 | .56 | .59 | .89 |
| 4 | | | | 1.00 | .55 | .88 |
| 5 | | | | | 1.00 | .90 |
| 6 | | | | | | 1.00 |

differing by four or five years. All but one correlation increases when rank rather than proportion correct is used, indicating that the relation between item performance and grade is nonlinear.

The rank correlations for the U.S. population, shown in the upper half of Table 11, exhibit little variability. They are higher for the U.S. population than for the Nicaraguan population (Table 10) indicating a more consistent order of relative difficulty across grades in the U.S. The exception to these high rank correlations are with Grade K, where all are lower. Also, the rank correlations between cultures, shown in the lower half of Table 11, are quite uniform, with the exception of those for U.S. Grade K.

Both the linear and the rank correlations are strongest for Nicaraguan Grades 1, 2, 3, and 6, but weaker for Grades 4 and 5. We have no explanation for this anomaly. One can hypothesize that if fourth- and fifth-grade students are mastering a substantial subset of the test content for the first time, their *relative* performance on those items would differ from that of the other grades. For example, if the two-digit addition and subtraction items in this test are learned during Grades 4 and 5, then the difficulty of these items vis-à-vis simpler addition and subtraction items will differ in these grades from that in either Grade 3 or 6.

TABLE 11

Rank Correlations Between Proportion Correct Among Grades for U.S. and Nicaraguan Students

| | | United States | | | | | |
|---|---|---|---|---|---|---|---|
| | Grade | K | 1 | 2 | 3 | 4 | 5 |
| United States | K | 1.00 | .75 | .72 | .75 | .74 | .73 |
| | 1 | | 1.00 | .96 | .96 | .96 | .94 |
| | 2 | | | 1.00 | .96 | .95 | .93 |
| | 3 | | | | 1.00 | .99 | .97 |
| | 4 | | | | | 1.00 | .98 |
| | 5 | | | | | | 1.00 |
| Nicaragua | 1 | .62 | .75 | .76 | .73 | .75 | .75 |
| | 2 | .62 | .76 | .77 | .75 | .77 | .77 |
| | 3 | .61 | .76 | .78 | .77 | .78 | .79 |
| | 4 | .61 | .70 | .71 | .70 | .70 | .68 |
| | 5 | .61 | .73 | .74 | .72 | .72 | .70 |
| | 6 | .69 | .83 | .84 | .86 | .85 | .86 |

TABLE 12

Concept Correlation Matrices
for Nicaraguan Students

| Grade | Concept | N[a] | A | S | T |
|---|---|---|---|---|---|
| 1 | N | 1.00 | .76 | .67 | .84 |
| | A | | 1.00 | .89 | .98 |
| | S | | | 1.00 | .94 |
| | T | | | | 1.00 |
| 2 | N | 1.00 | .71 | .66 | .81 |
| | A | | 1.00 | .81 | .96 |
| | S | | | 1.00 | .92 |
| | T | | | | 1.00 |
| 3 | N | 1.00 | .70 | .69 | .80 |
| | A | | 1.00 | .87 | .97 |
| | S | | | 1.00 | .94 |
| | T | | | | 1.00 |
| 4 | N | 1.00 | .56 | .51 | .66 |
| | A | | 1.00 | .83 | .97 |
| | S | | | 1.00 | .92 |
| | T | | | | 1.00 |
| 5 | N | 1.00 | .75 | .76 | .83 |
| | A | | 1.00 | .89 | .98 |
| | S | | | 1.00 | .95 |
| | T | | | | 1.00 |
| 6 | N | 1.00 | .72 | .62 | .77 |
| | A | | 1.00 | .87 | .98 |
| | S | | | 1.00 | .94 |
| | T | | | | 1.00 |

[a] N = number concepts, A = addition, S = subtraction, T = total test.

*Relation Between Concepts*

In all Nicaraguan grades, the relation between performance on pairs of concepts (e.g., addition and subtraction), indicated by a correlation coefficient, is quite strong (Table 12). In Grade 4, the relation between number concepts and both addition and subtraction is rather weak (correlations of .56 and .51, respectively). For the remaining grades, the correlation between number concepts and addition ranges from .70 to .76, and between number concepts and subtraction from .62 to .76. The correlations between addition and subtraction are all fairly high (.81 to .89). The correlation matrices for each grade are quite similar. In each grade the correlation between addition and subtraction is highest, followed by addition and number concepts and then by subtraction and number concepts.

The correlations between scores for concepts in the U.S. population are shown in Table 13. As with the Nicaraguan population, the highest correlation between concepts is between addition and subtrac-

TABLE 13

Concept Correlation Matrices
for U.S. Students

| Grade | Concept | N[a] | A | S | T |
|---|---|---|---|---|---|
| K | N | 1.00 | .83 | .81 | .88 |
| | A | | 1.00 | .95 | .99 |
| | S | | | 1.00 | .97 |
| | T | | | | 1.00 |
| 1 | N | 1.00 | .80 | .74 | .81 |
| | A | | 1.00 | .95 | .99 |
| | S | | | 1.00 | .98 |
| | T | | | | 1.00 |
| 2 | N | 1.00 | .73 | .69 | .76 |
| | A | | 1.00 | .92 | .98 |
| | S | | | 1.00 | .97 |
| | T | | | | 1.00 |
| 3 | N | 1.00 | .77 | .74 | .81 |
| | A | | 1.00 | .85 | .92 |
| | S | | | 1.00 | .94 |
| | T | | | | 1.00 |
| 4 | N | 1.00 | .67 | .64 | .83 |
| | A | | 1.00 | .90 | .95 |
| | S | | | 1.00 | .94 |
| | T | | | | 1.00 |
| 5 | N | 1.00 | .65 | .71 | .81 |
| | A | | 1.00 | .84 | .88 |
| | S | | | 1.00 | .89 |
| | T | | | | 1.00 |

[a] N = number concepts, A = addition, S = subtraction, T = total test.

tion. In the lower grades, the correlations are all lower for the Nicaraguan population (Table 12) than for the American population. This may indicate that instruction in these three concepts occurs simultaneously in the United States, whereas instruction occurs independently in Nicaragua. In the United States, the successful teaching of arithmetic concepts may depend on knowledge of previous concepts, whereas in Nicaragua it may be independent of previous concepts.

## 3. SUMMARY

An effort was made to adapt a U.S. version of the *Stanford Mental Arithmetic Test* to a Nicaraguan primary-school-age population. Care was taken to assure an adequate translation from the American English version to the Nicaraguan Spanish version. The result was a Spanish test with a longer introduction to familiarize students with the item indices and test format. Nicaraguan norms were developed for Grades 1 through 6, including grade-equivalent, age-equivalent, and percentile scores.

The item sequence was found to be adequate in ordering the items by difficulty for all Nicaraguan grades. The relative difficulty of the items is similar for pairs of grades, any difference in difficulty increasing with the difference in grade. An exception was with Grades 4 and 5, where correlations between proportion correct were lower. The concept correlation matrices for all grades are quite similar, with the strongest correlation between addition and subtraction. The means increase monotonically with grade as well as with age. However, an analysis by age within grade indicates that the increasing score with age is due mainly to grade level; that is, there is a stronger relation between score and grade within age than between score and age within each grade.

Comparing the Nicaraguan mental arithmetic performance to that of the U.S. population, we found that the items were arranged in order of difficulty more for the U.S. population than for the Nicaraguan population. For the Nicaraguan population the ordering seems to be best for the upper grades; for the U.S. population it is best for the middle grades. The relative difficulties of items across the two cultures between concepts were generally lower among the Nicaraguan grades than among the U.S. grades.

These results indicate that Nicaraguan students perform somewhat differently than do U.S. students on mental arithmetic. The differences in relative performance suggest that the mental arithmetic curriculum may be distributed differentially throughout the primary school years.

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# APPENDIX A

## SYMBOLIC AND ORAL FORMS OF ARITHMETIC EXERCISES

| Symbolic form | English oral form | Spanish oral form |
|---|---|---|
|  | Write the number 1. | Escriban el número 1. |
|  | Which is bigger, 0 or 3? | ¿Cuál número es mayor, el 0 o el 3? |
|  | What comes after/before/ between 5 (and 7)? | ¿Qué número va después/antes/ entre del 5 (y 7)? |
| 3 + 2 = ___ | What is 3 plus 2? | ¿Cuánto es 3 más 2? |
| 3 + ___ = 5 | 3 plus what equals 5? | ¿3 más cuánto es igual a 5? |
| ___ + 2 = 5 | What plus 2 equals 5? | ¿Qué número más 2 es igual a 5? |
| 5 − 2 = ___ | What is 5 take away 2? | ¿Cuánto es 5 menos 2? |
| 5 − ___ = 3 | 5 take away what equals 3? | ¿5 menos cuánto es igual a 3? |
| ___ − 2 = 3 | What take away 2 equals 3? | ¿Qué número menos 2 es igual a 3? |

# APPENDIX B

## SCRIPT FOR THE STANFORD MENTAL ARITHMETIC TEST

This is a new kind of math test to see how well you can do arithmetic in your head. Here is how it works:

I will read you a question. Then you do the problem in your head and write the answer on your paper. **Do not write the question on your paper,** only the answer. Many of the problems may be very hard. If you cannot do the problem in your head, then do **NOT** write anything on your paper for that problem—just leave a space and go on to the next problem. I will say each problem once. If you do not hear the question, then leave a space and wait for the next problem. There is not very much time between the questions, so you will have to listen **VERY** carefully. If you talk, you may not hear the next question. Listen very hard, and **PLEASE, NO TALKING.**

Let us do some problems together first. Look at your answer sheets.
*pause*
Now find where it says PART 1.

**TEACHER INDICATES:** PART 1

There are blank lines under it. Find the first blank line with an A under PART 1.

**TEACHER INDICATES:** PART 1
A _

Now let's do the problem A and the answer together.

A. Write the number 2, the number 2.
*pause*

That one is pretty easy, isn't it? All you have to do is put the number 2 on your paper on the first blank line next to the letter A.

**TEACHER INDICATES:** PART 1
A 2

Write the answer after the letter B.

B. What comes after 4, after 4?

Don't tell me. Think the answer.
*pause*

The answer is 5. Have you written the number 5 on the blank line next to the letter B?

**TEACHER INDICATES:** PART 1
A 2
B 5

Write only the answer. Remember, don't say the answer out loud. **LISTEN** to the question, **THINK** the answer. Do not write the question. Write only the answer on the blank line.

Let's do problem C together, too. Think the answer and write the number next to C.

C. What is 3 plus 1?
*pause*

Did you write the number 4 on the C line? Good!

**TEACHER INDICATES:** PART 1
A 2
B 5
C 4

Now let's do D. Think the answer and write the number next to D.

D. What is 4 take away 1?
*pause*

Did you write the number 3 on the D line? Good!

**TEACHER INDICATES:** PART 1
A 2
B 5
C 4
D 3
E __

Remember, do not write the question. If you don't hear the question, just wait for the next one. Let's do another one, E.

E. What plus 2 equals 4?
*pause*

Did you write the number 2 on the line? Good!

**TEACHER INDICATES:** PART 1

A 2
B 5
C 4
D 3
E 2

The problems at the beginning of the test are easier than the problems at the end of the test. No one will finish the test. So, when you cannot do any more problems, just stop and close your test booklet. Everyone will stop before the end of the test.

Now open your test booklets to the back of the page that you have just written on. It should say page 2 in the corner *(indicate with booklet)*. Look at the top of the page. Do you see where it says PART 2? **TEACHER INDICATES.** You will begin here. Put your first answer on the line next to the letter A. Ready? Then we can begin.

A. Write the number 1.
B. Which is bigger, 0 or 3?
C. What is 3 plus 2?
D. 3 plus what equals 5?
E. Which is bigger, 9 or 6?
AA. What comes between 0 and 2?
BB. Write the number 17.
CC. Which is bigger, 15 or 19?
DD. 2 plus what equals 8?
EE. What is 1 plus 2?

Now move across the page to where it says PART 3. Remember, no talking! Ready? Then we can begin.

A. What is 10 plus 2?
B. What is 5 take away 2?
C. Write the number 29.
D. What is 8 plus 0?

E. Write the number 20.
AA. What comes before 11?
BB. What plus 4 equals 7?
CC. Which is bigger, 84 or 27?
DD. What comes between 16 and 18?
EE. What comes between 6 and 8?

Keep moving across the page to where it says PART 4. Remember, no talking! Ready? Begin.

A. Which is bigger, 34 or 91?
B. 0 plus what equals 2?
C. What is 7 take away 4?
D. What is 6 plus 7?
E. What is 10 plus 9?
AA. What is 1 plus 4?
BB. 4 take away what equals 2?
CC. 1 plus what equals 6?
DD. What plus 6 equals 6?
EE. What is 5 plus 10?

Keep moving across the page to where it says PART 5. Remember, no talking! Ready? Begin.

A. What is 8 take away 4?
B. 3 plus what equals 13?
C. 3 plus what equals 10?
D. What is 2 plus 1 plus 5?
E. What is 11 plus 3?
AA. What is 8 plus 9?
BB. What is 12 take away 2?
CC. What plus 10 equals 12?
DD. What is 10 take away 9?
EE. 3 take away what equals 2?

We will stop now so that you can rest for awhile. You can close your test booklets and I will see you in a few minutes.

*pause 90 sec.*

Hello! I am back again. Are you sitting in your seats? Are you ready to continue? Good. Open your test booklets to the first page that you have not written on.

*pause*

Look at the top of the page. We will continue here where it says PART 6. I hope that everyone has found Part 6. Remember, no talking! Ready? Begin.

A. What plus 6 equals 14?
B. What is 17 take away 7?
C. 9 plus what equals 17?
D. What plus 10 equals 19?
E. 8 plus what equals 28?
AA. What is 13 take away 10?
BB. What is 5 plus 12?
CC. Write the number 573.
DD. 12 plus what equals 14?
EE. What is 91 plus 7?

Now move across the page to where it says PART 7. Remember, no talking! Ready? Then we can begin.

A. What comes between 89 and 91?
B. What is 10 plus 70?
C. What is 12 take away 7?
D. What plus 13 equals 14?
E. What is 20 plus 70?
AA. What is 75 take away 5?
BB. 3 plus what equals 15?
CC. What take away 3 equals 2?
DD. 16 take away what equals 6?
EE. What is 5 plus 32?

Keep moving across the page to where it says PART 8. Remember, no talking! Ready? Begin.

A. What plus 70 equals 75?
B. What is 13 take away 2?
C. What is 80 take away 10?
D. What is 19 take away 10?
E. What is 12 take away 11?
AA. What is 16 take away 4?
BB. What is 2 plus 336?
CC. What plus 13 equals 16?
DD. What is 90 take away 80?
EE. What is 55 take away 50?

Keep moving across the page to where it says PART 9. Remember, no talking! Ready? Begin.

A. What is 4 plus 17?
B. What plus 10 equals 80?

C. What is 38 plus 9?
D. 59 take away what equals 9?
E. What plus 30 equals 40?
AA. What take away 7 equals 2?
BB. What is 15 take away 7?
CC. What plus 40 equals 90?
DD. What plus 2 equals 48?
EE. 7 take away 0 equals 8 take away what?

We will stop now so that you can rest for awhile. You can close your test booklets and I will see you in a few minutes.

*pause 90 sec.*

Hello! I am back again. Are you sitting in your seats? Are you ready to continue? Good. Turn your test booklets to the back page. Look at the top of the page. We will continue here where it says PART 10. I hope that everyone has found Part 10. Remember, no talking! Ready? Begin.

A. What is 9 plus 36?
B. 16 take away what equals 8?
C. What take away 5 equals 1?
D. What plus 86 equals 89?
E. What take away 4 equals 10?
AA. What is 34 plus 35?
BB. 90 take away what equals 20?
CC. 50 plus what equals 130?
DD. What is 80 take away 30?
EE. What is 6 plus 5 plus 8?

Now move across the page to where it says PART 11. Remember, no talking! Ready? Then we can begin.

A. What is 9 plus 4 plus 8?
B. 6 plus 5 equals 10 plus what?
C. 13 take away what equals 2?
D. What is 93 plus 700?
E. 43 plus what equals 73?
AA. 4 plus what equals 57?
BB. What is 120 take away 40?
CC. What take away 9 equals 10?
DD. What take away 10 equals 2?
EE. What is 400 plus 25?

You may now close your test booklets. I hope that you have enjoyed doing arithmetic problems in your head. Thank you.

# APPENDIX C

## TEXTO DE LA PRUEBA DE CÁLCULO MENTAL DE LA UNIVERSIDAD DE STANFORD

Esta es una nueva clase de prueba. Ustedes van a resolver problemas de matemática en su cabeza. Aquí está la forma como se hace:

Yo les leeré una pregunta. Después ustedes harán el problema en su cabeza y escribirán la respuesta en su hoja de respuestas. **No escriban la pregunta en su hoja de respuestas,** sólo la respuesta. No habrá mucho tiempo entre las preguntas, así que ustedes tienen que escuchar con mucho cuidado. Si ustedes hablan, tal vez no puedan oír la siguiente pregunta. Así que, escuchen con cuidado y **no hablen, por favor.**

Primero, haremos algunos problemas juntos. Vean sus hojas de respuestas. Ahora encuentren donde dice . . . Parte 1. Hay letras debajo. Cada letra tiene una línea al lado. Ahora niños, trabajaremos en su hoja de respuestas. ¿Listos?

Pongan el dedo en la letra A.
Pongan el dedo en la letra B.
Pongan el dedo en la letra C.
Pongan el dedo en la letra D.
Pongan el dedo en la letra E.
Pongan el dedo en la letra AA.
Pongan el dedo en la letra BB.
Pongan el dedo en la letra CC.
Pongan el dedo en la letra DD.
Pongan el dedo en la letra EE.

Encuentren la primera línea, la que tiene una A debajo de la parte 1. Ahora haremos el problema A y contestemos todos juntos. Pongan el dedo en la letra A.

A. Escriban el número 2, el número 2.

Ése problema es muy fácil, ¿verdad? Todo lo que tienen que hacer es poner el número 2 en su hoja de respuestas, en la primera línea al lado de la letra A. Ahora haremos el problema B. Pongan el dedo en la letra B.

B. ¿Qué número va después del 3, después del 3?

Escriban la respuesta al lado de la letra B. No contesten en voz alta. Piensen en la respuesta. La respuesta es 4. ¿Han escrito ustedes el número 4 en la línea que está al lado de la letra B? Escriban sólo la respuesta. Recuerden, no digan la respuesta en voz alta. Escuchen la pregunta. Piensen en la respuesta. No escriban la pregunta. Escriban solamente la respuesta en la línea. Haremos el problema C, juntos también. Pongan el dedo en la letra C. Piensen en la respuesta y escriban el número al lado de la letra C.

C. ¿Cuál número es mayor el 0 o el 3?

¿Escribieron el número 3 en la línea de la C? Bien. Ahora haremos el problema D. Pongan el dedo en la letra D.

D. ¿Qué número va antes del 3?
*pausa–6 segundos*

¿Escribieron ustedes el número 2 en la línea D? Bien. Recuerden, no escriban la pregunta. Si ustedes no oyen la pregunta, unicamente esperen la siguiente. Haremos uno más, el de la letra E. Pongan el dedo en la letra E.

E. ¿Cuánto es 4 más 1?

¿Escribieron ustedes el número 5 en la línea E.? Bien. Muchos de los problemas tal vez sean muy difíciles. Si ustedes no pueden hacer el problema en su cabeza, no escriban nada en su hoja de respuestas para ése problema. Sólo dejen un espacio y pasen al siguiente problema. Yo diré cada problema una vez. Si ustedes no oyen la pregunta, dejen un espacio y esperen el siguiente problema. Ahora, hagamos unos problemas más. Encuentren la línea que tiene las letras AA. Pongan el dedo en las letras AA.

AA. ¿Qué número va entre tres y cinco?

¿Escribieron el número 4 en la línea AA? Bien. Ahora haremos el problema BB. Pongan el dedo en las letras BB.

BB. ¿Cuánto es 10 más 6?

¿Escribieron el número 16 en la línea BB? Bien. Ahora haremos el problema CC.

CC. ¿2 más cuánto es igual a 3?

¿Escribieron el número uno en la línea CC? Bien. Ahora haremos el problema DD.

DD. ¿Cuánto es 4 menos 1?

¿Escribieron el número 3 en la línea DD? Bien. Ahora haremos el problema EE.

EE. ¿Qué número más 2 es igual a 4?

¿Escribieron el número 2 en la línea EE? Bien.

Los problemas al comienzo de esta prueba son más fáciles que los problemas al final de la prueba. Ninguno terminará la prueba. Así que cuando ustedes no puedan hacer más problemas, deténganse y cierren sus hojas de respuestas. Todos se detendrán antes del final de la prueba.

Ahora pasemos a la parte de atrás de la hoja de respuestas en que ustedes acaban de escribir. Dice página 2 en la esquina. Vean arriba de la página. ¿Ven donde dice parte 2? Ahí van a comenzar. Bien. Ahora escribiran su primera respuesta al lado de la letra A. ¿Listos? Ahora podemos comenzar.

A. Escriban el número 1.
B. ¿Cuál número es mayor, el 0 o el 3?
C. ¿Cuánto es 3 más 2?
D. ¿3 más cuánto es igual a 5?
E. ¿Cuál número es mayor, el 9 o el 6?
AA. ¿Qué número va entre 0 y 2?
BB. Escriban el número 17.
CC. ¿Cuál número es mayor, el 15 o el 19?
DD. ¿2 más cuánto es igual a 8?
EE. ¿Cuánto es 1 más 2?

Ahora pasen a la siguiente columna hasta donde dice . . . Parte 3. Recuerden, no hablen. ¿Listos? Ahora podemos comenzar.

A. ¿Cuánto es 10 más 2?
B. ¿Cuánto es 5 menos 2?
C. Escriban el número 29.
D. ¿Cuánto es 8 más 0?
E. Escriban el número 20.
AA. ¿Qué número va antes del 11?
BB. ¿Qué número más 4 es igual a 7?
CC. ¿Cuál número es mayor, el 84 o el 27?
DD. ¿Qué número va entre 16 y 18?
EE. ¿Qué número va entre 6 y 8?

Pasen a la siguiente columna hasta donde dice . . . Parte 4. Recuerden, no hablen. ¿Listos? Comencemos.

A. ¿Cuál número es mayor, el 34 o el 91?
B. ¿0 más cuánto es igual a 2?
C. ¿Cuánto es 7 menos 4?
D. ¿Cuánto es 6 más 7?
E. ¿Cuánto es 10 más 9?
AA. ¿Cuánto es 1 más 0 más 4?
BB. ¿5 menos cuánto es igual a 2?
CC. ¿1 más cuánto es igual a 6?
DD. ¿Qué número más 6 es igual a 6?
EE. ¿Cuánto es 5 más 10?

Pasen a la siguiente columna hasta donde dice . . . Parte 5. Recuerden, no hablen. ¿Listos? Comencemos.

A. ¿Cuánto es 8 menos 4?
B. ¿3 más cuánto es igual a 13?
C. ¿3 más cuánto es igual a 10?
D. ¿Cuánto es 2 más 1 más 5?
E. ¿Cuánto es 11 más 3?
AA. ¿Cuánto es 8 más 9?
BB. ¿Cuánto es 12 menos 2?
CC. ¿Qué número más 10 es igual a 12?
DD. ¿Cuánto es 10 menos 9?
EE. ¿3 menos cuánto es igual a 2?

Ahora nos detendremos para descansar por un rato. Nos veremos en unos pocos minutos.

*Descanso—pausa-90 segundos*

¡Hola! Estoy de nuevo con ustedes. ¿Están listos para continuar? Bien. Abran las hojas de respuestas, hasta la primera página en la que no han escrito. Vean arriba de la página. Continuaremos ahí donde dice . . . Parte 6. Yo espero que todos hayan encontrado la parte 6. Recuerden, no hablen. ¿Listos? Comencemos.

A. ¿Qué número más 6 es igual a 14?
B. ¿Cuánto es 17 menos 7?
C. ¿9 más cuánto es igual a 17?
D. ¿Qué número más 10 es igual a 19?
E. ¿8 más cuánto es igual a 28?
AA. ¿Cuánto es 13 menos 10?

BB. ¿Cuánto es 5 más 12?
CC. Escriban el número 573.
DD. ¿12 más cuánto es igual a 14?
EE. ¿Cuánto es 91 más 7?

Ahora pasen a la siguiente columna hasta donde dice . . . Parte 7. Recuerden, no hablen. ¿Listos? Entonces podemos comenzar.

A. ¿Qué número va entre 89 y 91?
B. ¿Cuánto es 10 más 70?
C. ¿Cuánto es 12 menos 7?
D. ¿Qué número más 13 es igual a 14?
E. ¿Cuánto es 20 más 70?
AA. ¿Cuánto es 75 menos 5?
BB. ¿3 más cuánto es igual a 15?
CC. ¿Qué número menos 3 es igual a 2?
DD. ¿16 menos cuánto es igual a 6?
EE. ¿Cuánto es 5 más 32?

Pasen a la siguiente columna hasta donde dice . . . Parte 8. Recuerden, no hablen. ¿Listos? Comencemos.

A. ¿Qué número más 70 es igual a 75?
B. ¿Cuánto es 13 menos 2?
C. ¿Cuánto es 80 menos 10?
D. ¿Cuánto es 19 menos 10?
E. ¿Cuánto es 12 menos 11?
AA. ¿Cuánto es 16 menos 4?
BB. ¿Cuánto es 2 más 336?
CC. ¿Qué número más 13 es igual a 16?
DD. ¿Cuánto es 90 menos 80?
EE. ¿Cuánto es 55 menos 50?

Pasen a la siguiente columna hasta donde dice . . . Parte 9. Recuerden, no hablen. ¿Listos? Comencemos.

A. ¿Cuánto es 4 más 17?
B. ¿Qué número más 10 es igual a 80?
C. ¿Cuánto es 38 más 9?
D. ¿59 menos cuánto es igual a 9?
E. ¿Qué número más 30 es igual a 40?
AA. ¿Qué número menos 7 es igual a 2?
BB. ¿Cuánto es 15 menos 7?

CC. ¿Qué número más 40 es igual a 90?
DD. ¿Qué número más 2 es igual a 48?
EE. ¿7 menos 0 is igual a 8 menos cuánto?

Ahora nos detendremos para que podamos descansar por un rato. Nos veremos en unos pocos minutos.

*Descanso—pausa-90 segundos*

¡Hola! Aquí estoy de nuevo. ¿Están listos para continuar? Bien. Den vuelta a la última página de la hoja de respuestas, la que tiene solamente dos columnas. Vean arriba de la página. Continuaremos ahí donde dice . . . Parte 10. Espero que todos hayan encontrado la parte 10. Recuerden, no hablen. ¿Listos? Comencemos.

A. ¿Cuánto es 9 más 36?
B. ¿16 menos cuánto es igual a 8?
C. ¿Qué número menos 5 es igual a 1?
D. ¿Qué número más 86 es igual a 89?
E. ¿Qué número menos 4 es igual a 10?
AA. ¿Cuánto es 34 más 35?
BB. ¿90 menos cuánto es igual a 20?
CC. ¿50 más cuánto es igual a 130?
DD. ¿Cuánto es 80 menos 30?
EE. ¿Cuánto es 6 más 5 más 8?

Pasen a la siguiente columna hasta donde dice . . . Parte 11. Recuerden, no hablen. ¿Listos? Entonces comencemos.

A. ¿Cuánto es 9 más 4 más 8?
B. ¿6 más 5 es igual a 10 más cuánto?
C. ¿13 menos cuánto es igual a 2?
D. ¿Cuánto es 93 más 700?
E. ¿43 más cuánto es igual a 73?
AA. ¿4 más cuánto es igual a 57?
BB. ¿Cuánto es 120 menos 40?
CC. ¿Qué número menos 9 es igual a 10?
DD. ¿Qué número menos 10 es igual a 2?
EE. ¿Cuánto es 400 más 25?

Ahora cierren sus hojas de respuestas. Espero que hayan disfrutado haciendo los problemas de matemática en su cabeza. Gracias.

# APPENDIX D

## MANUAL FOR NICARAGUAN MENTAL ARITHMETIC TEST

### *Administration of Tests*

No special training in testing is necessary for the SMAT test administration; tests can be both administered and scored by following the specified procedures. The tests are administered to an entire class using a prerecorded tape of the exercises. In this way each exercise is presented uniformly to all students. Testing results will be most meaningful if the testing room is quiet, well lighted and ventilated, and comfortable in temperature, and if seating is arranged to discourage copying. Answer sheets are distributed to all students.

Students are instructed to write only the answer and not the problem statement. Instructions are given to cross out rather than erase each answer a student wants to change.

### *Procedures for Scoring Tests*

Students' answers are given in a free-response form. Scoring rules for the SMAT are as follows:

1. Any answer involving an erasure is marked incorrect.
2. If a student writes down the question, his answer is automatically marked incorrect.
3. Answers must be written on the correct line in order to be marked correct; a right answer in the wrong place is wrong, even if the scorer feels that the student knows the answer to the question.
4. Omitted answers are marked incorrect.
5. If more than one answer is given, the item is marked incorrect.
6. Single digits written backwards are counted correct (e.g.,Ɛ for 3), but transposed digits are incorrect (e.g., 53 for 35).
7. Sample items not scored. They are provided to help the student understand what he is to do on the test itself.
8. If an answer has been crossed out and replaced by another answer, the final response is scored.
9. No partial credit is given for any item. Each item is either correct or incorrect.
10. The raw score for each test is the number of correct answers.

### *Interpretation of Tests*

Test interpretation should be made by persons having at least some experience with grade-placement scores and percentile rankings. Interpretations intended for the test as a whole are also applicable to *concept scores*, although the latter measurements are somewhat less stable. The total test score provides a measure of the student's overall mental arithmetic achievement. The concept scores describe how well the student has done in each of the separate concepts.

### *Grade-equivalent Scores*

Grade placement scores are given in tenths of a school year. The grade placement for any testing date may be determined from Table D–1, in which the appropriate dates are given for dividing the Nicaraguan school year into tenths.

Comparison of a student's score with students at other grade placements may be made using grade norms. The grade placement at time of testing may be compared with the student's grade equivalent from his test score. The grade equivalent indicates the median score made by students at a particular grade placement.

The grade equivalent corresponding to each raw score may be found for concept and total test scores in Table D–2. For example, consider two second-grade students who are administered the SMAT in September. They are at grade level 2.7. Suppose that John, age 7, answers 63 items correctly, of which 22 were addition exercises. Locate his scores on the table. His total score corresponds to a grade equivalent of 4.47. This means that his performance equals the performance of the median student at grade level 4.47. He is well above his actual grade level on mental arithmetic skills. His addition score, found in the table, corresponds to a grade equivalent of 3.21. He is only slightly above his actual grade level on mental addition exercises.

Suppose that Mary, age 9, answers 67 items correctly, of which 33 were addition exercises. Her total score has a grade equivalent of 4.92, and her addition score has a grade equivalent of 4.58. Her addition and total score have approximately the same grade equivalent, and both are above her actual grade placement.

### *Age-equivalent Scores*

The age equivalent corresponding to each raw score may be found for total test scores in Table D–3. Only ages 7 to 16 were used, due to the small sample sizes for ages 6, 17, and 18.

Using the examples from the previous section, we locate John's total score, 63 under the column labeled "Raw score" in Table D–3. His age-equivalent score is 12.32 We conclude that John is well above the average student at his age, 7, on mental arithmetic skills, as is Mary, with an age-equivalent score of 12.86.

### *Percentile Ranks*

Comparison of a student's score with students at the same grade placement may be made using percentile ranks. The percentile rank corresponding to a raw score indicates the percentage of students in that grade placement having scores less than the given score. Percentile ranks corresponding to raw scores for concept and total test scores are given by grade and age in Tables D–4 and D–5 respectively.

Using the examples from the previous section, locate the row for John's total score, 63 in Table D–4. Under the column for grade placement 2.7 find his percentile. This score is at the 88th percentile for this grade which means that 88 percent of the students in the norming group at grade 2.7 perform more poorly than John. He is clearly above average for his grade level. Mary's total score is 67. She is at the 91st percentile for her grade level.

In Table D–5 locate the column for John's age, 7. He is at the 99th percentile for his age, which means that 99 percent of the seven-year-old students in the norming group performed more poorly than John. Mary is at the 88th percentile for her age, 9.

### *Conversion of Raw Scores to Grade-equivalent, Age-equivalent, and Percentile Scores*

**Raw score.** Count the number of correct answers for each concept.

**Grade equivalent.** Locate the column in Table D–2 corresponding to the relevant concept. Locate the grade equivalent corresponding to each raw score.

**Age equivalent.** Locate the age equivalent corresponding to the total raw score in Table D–3

**Percentile by grade.** Locate the column in Table D–4 corresponding to the appropriate grade level. Locate the section corresponding to the relevant concept. Locate the row corresponding to the raw score. The entry in this column and row is the percentile rank for students in that grade.

**Percentile by age.** Locate the column in Table D–5 corresponding to the appropriate age. Locate the row corresponding to the total raw score. The entry in this column and row is the percentile rank for students of that age.

## TABLE D-1

### Grade Placement at Time of Testing in Nicaragua

| Dates | Grade placement |
|---|---|
| Feb 1–Feb 28 | .0 |
| Mar 1–Mar 31 | .1 |
| Apr 1–Apr 31 | .2 |
| May 1–May 31 | .3 |
| Jun 1–Jun 30 | .4 |
| Jul 1–Jul 31 | .5 |
| Aug 1–Aug 31 | .6 |
| Sep 1–Sep 30 | .7 |
| Oct 1–Oct 31 | .8 |
| Nov 1–Nov 30 | .9 |

## TABLE D-2

### Raw Score to Grade Equivalent Conversions for Concept and Total Scores

| Raw score | Concept | | | | Raw score | Concept | | | |
|---|---|---|---|---|---|---|---|---|---|
| | N[a] | A | S | T | | N | A | S | T |
| 1 | *[b] | * | * | * | 16 | | 2.63 | 2.60 | 1.93 |
| 2 | * | * | * | * | 17 | | 2.72 | 2.76 | 1.97 |
| 3 | * | * | * | * | 18 | | 2.82 | 2.93 | 2.01 |
| 4 | * | 1.74 | * | * | 19 | | 2.91 | 3.11 | 2.04 |
| 5 | * | 1.80 | * | * | 20 | | 3.01 | 3.30 | 2.08 |
| 6 | * | 1.87 | * | * | 21 | | 3.11 | 3.50 | 2.12 |
| 7 | * | 1.93 | * | * | 22 | | 3.21 | 3.72 | 2.16 |
| 8 | 1.86 | 2.00 | * | * | 23 | | 3.32 | 3.95 | 2.20 |
| 9 | 2.27 | 2.07 | 1.71 | 1.70 | 24 | | 3.43 | 4.19 | 2.24 |
| 10 | 2.76 | 2.15 | 1.82 | 1.73 | 25 | | 3.55 | 4.45 | 2.28 |
| 11 | 3.37 | 2.22 | 1.93 | 1.76 | 26 | | 3.66 | 4.72 | 2.32 |
| 12 | 4.10 | 2.30 | 2.05 | 1.80 | 27 | | 3.78 | 5.01 | 2.37 |
| 13 | 4.98 | 2.38 | 2.17 | 1.83 | 28 | | 3.90 | 5.32 | 2.41 |
| 14 | 6.06 | 2.46 | 2.31 | 1.86 | 29 | | 4.03 | 5.64 | 2.45 |
| 15 | * | 2.55 | 2.45 | 1.90 | 30 | | 4.16 | 5.99 | 2.50 |

(TABLE D-2, cont.)

| Raw score | Concept |  |  |  | Raw score | Concept |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | N | A | S | T |  | N | A | S | T |
| 31 |  | 4.30 | 6.36 | 2.54 | 66 |  |  |  | 4.83 |
| 32 |  | 4.43 | 6.75 | 2.59 | 67 |  |  |  | 4.92 |
| 33 |  | 4.58 | * | 2.64 | 68 |  |  |  | 5.01 |
| 34 |  | 4.72 |  | 2.69 | 69 |  |  |  | 5.10 |
| 35 |  | 4.87 |  | 2.74 | 70 |  |  |  | 5.19 |
| 36 |  | 5.02 |  | 2.79 | 71 |  |  |  | 5.29 |
| 37 |  | 5.18 |  | 2.84 | 72 |  |  |  | 5.39 |
| 38 |  | 5.34 |  | 2.89 | 73 |  |  |  | 5.49 |
| 39 |  | 5.51 |  | 2.95 | 74 |  |  |  | 5.59 |
| 40 |  | 5.68 |  | 3.00 | 75 |  |  |  | 5.69 |
| 41 |  | 5.87 |  | 3.06 | 76 |  |  |  | 5.79 |
| 42 |  | 6.04 |  | 3.11 | 77 |  |  |  | 5.90 |
| 43 |  | 6.22 |  | 3.17 | 78 |  |  |  | 6.01 |
| 44 |  | 6.41 |  | 3.23 | 79 |  |  |  | 6.12 |
| 45 |  | 6.61 |  | 3.29 | 80 |  |  |  | 6.23 |
| 46 |  | * |  | 3.35 | 81 |  |  |  | 6.35 |
| 47 |  | * |  | 3.41 | 82 |  |  |  | 6.47 |
| 48 |  | * |  | 3.47 | 83 |  |  |  | 6.58 |
| 49 |  | * |  | 3.54 | 84 |  |  |  | 6.71 |
| 50 |  | * |  | 3.60 | 85 |  |  |  | * |
| 51 |  | * |  | 3.67 | 86 |  |  |  | * |
| 52 |  | * |  | 3.74 | 87 |  |  |  | * |
| 53 |  |  |  | 3.81 | 88 |  |  |  | * |
| 54 |  |  |  | 3.88 | 89 |  |  |  | * |
| 55 |  |  |  | 3.95 | 90 |  |  |  | * |
| 56 |  |  |  | 4.02 | 91 |  |  |  | * |
| 57 |  |  |  | 4.09 | 92 |  |  |  | * |
| 58 |  |  |  | 4.17 | 93 |  |  |  | * |
| 59 |  |  |  | 4.25 | 94 |  |  |  | * |
| 60 |  |  |  | 4.33 | 95 |  |  |  | * |
| 61 |  |  |  | 4.41 | 96 |  |  |  | * |
| 62 |  |  |  | 4.49 | 97 |  |  |  | * |
| 63 |  |  |  | 4.47 | 98 |  |  |  | * |
| 64 |  |  |  | 4.65 | 99 |  |  |  | * |
| 65 |  |  |  | 4.74 | 100 |  |  |  | * |

5

---

[a] N = number concepts, A = addition, S = subtraction, T = total test.

[b] A "*" indicates that the prediction was outside of the range of grades tested and thus out of the range of accuracy.

## TABLE D–3

## Raw Score to Age Equivalent Conversions for Total Score

| Raw score | Age equivalent | Raw score | Age equivalent | Raw score | Age equivalent | Raw score | Age equivalent |
|---|---|---|---|---|---|---|---|
| 1 | *[a] | 26 | 8.26 | 51 | 10.82 | 76 | 14.17 |
| 2 | * | 27 | 8.35 | 52 | 10.94 | 77 | 14.33 |
| 3 | * | 28 | 8.44 | 53 | 11.06 | 78 | 14.48 |
| 4 | * | 29 | 8.53 | 54 | 11.18 | 79 | 14.64 |
| 5 | * | 30 | 8.62 | 55 | 11.30 | 80 | 14.80 |
| 6 | * | 31 | 8.72 | 56 | 11.42 | 81 | 14.96 |
| 7 | * | 32 | 8.81 | 57 | 11.54 | 82 | 15.12 |
| 8 | * | 33 | 8.91 | 58 | 11.67 | 83 | 15.28 |
| 9 | * | 34 | 9.01 | 59 | 11.80 | 84 | 15.45 |
| 10 | * | 35 | 9.10 | 60 | 11.92 | 85 | 15.62 |
| 11 | 7.02 | 36 | 9.20 | 61 | 12.05 | 86 | 15.79 |
| 12 | 7.10 | 37 | 9.30 | 62 | 12.18 | 87 | 15.96 |
| 13 | 7.18 | 38 | 9.40 | 63 | 12.32 | 88 | 16.13 |
| 14 | 7.25 | 39 | 9.50 | 64 | 12.45 | 89 | 16.31 |
| 15 | 7.33 | 40 | 9.61 | 65 | 12.59 | 90 | 16.48 |
| 16 | 7.41 | 41 | 9.71 | 66 | 12.72 | 91 | 16.66 |
| 17 | 7.49 | 42 | 9.82 | 67 | 12.86 | 92 | 16.84 |
| 18 | 7.58 | 43 | 9.92 | 68 | 13.00 | 93 | 17.03 |
| 19 | 7.66 | 44 | 10.03 | 69 | 13.14 | 94 | * |
| 20 | 7.74 | 45 | 10.14 | 70 | 13.28 | 95 | * |
| 21 | 7.83 | 46 | 10.25 | 71 | 13.43 | 96 | * |
| 22 | 7.91 | 47 | 10.36 | 72 | 13.58 | 97 | * |
| 23 | 8.00 | 48 | 10.48 | 73 | 13.72 | 98 | * |
| 24 | 8.08 | 49 | 10.59 | 74 | 13.87 | 99 | * |
| 25 | 8.17 | 50 | 10.70 | 75 | 14.02 | 100 | * |

[a] A "*" indicates that the prediction was outside of the range of grades tested and thus out of the range of accuracy.

## TABLE D-4

### Percentiles for Concepts by Grade Placement

| Score | Grade placement | | | | | |
|---|---|---|---|---|---|---|
| | 1.7 | 2.7 | 3.6 | 4.6 | 5.7 | 6.7 |
| | Number concepts | | | | | |
| 0 | 9 | 3 | 3 | 2 | 4 | 2 |
| 1 | 27 | 3 | 3 | 2 | 4 | 2 |
| 2 | 43 | 4 | 4 | 2 | 4 | 2 |
| 3 | 52 | 6 | 4 | 2 | 4 | 2 |
| 4 | 60 | 9 | 4 | 2 | 4 | 2 |
| 5 | 66 | 13 | 6 | 2 | 4 | 2 |
| 6 | 75 | 19 | 9 | 2 | 4 | 2 |
| 7 | 80 | 27 | 14 | 3 | 4 | 2 |
| 8 | 84 | 37 | 19 | 3 | 5 | 2 |
| 9 | 87 | 45 | 24 | 6 | 5 | 2 |
| 10 | 91 | 54 | 34 | 11 | 7 | 3 |
| 11 | 94 | 63 | 44 | 20 | 1 | 6 |
| 12 | 95 | 74 | 53 | 29 | 16 | 10 |
| 13 | 97 | 86 | 70 | 46 | 30 | 13 |
| 14 | 99 | 95 | 85 | 72 | 63 | 41 |
| 15 | 100 | 100 | 100 | 100 | 100 | 100 |
| | Addition | | | | | |
| 0 | 19 | 4 | 3 | 2 | 4 | 2 |
| 1 | 29 | 5 | 4 | 2 | 4 | 2 |
| 2 | 37 | 5 | 4 | 2 | 4 | 2 |
| 3 | 47 | 7 | 4 | 2 | 4 | 2 |
| 4 | 55 | 7 | 4 | 2 | 4 | 2 |
| 5 | 62 | 11 | 4 | 2 | 4 | 2 |
| 6 | 67 | 12 | 4 | 2 | 4 | 2 |
| 7 | 70 | 12 | 5 | 3 | 4 | 2 |
| 8 | 73 | 15 | 7 | 3 | 4 | 2 |
| 9 | 75 | 17 | 8 | 3 | 4 | 2 |
| 10 | 79 | 19 | 9 | 3 | 4 | 2 |
| 11 | 83 | 23 | 9 | 3 | 4 | 2 |
| 12 | 84 | 27 | 11 | 3 | 4 | 2 |
| 13 | 86 | 33 | 14 | 4 | 4 | 2 |
| 14 | 88 | 38 | 15 | 5 | 4 | 2 |

(TABLE D-4, cont.)

| Score | Grade placement | | | | | |
|---|---|---|---|---|---|---|
| | 1.7 | 2.7 | 3.6 | 4.6 | 5.7 | 6.7 |
| 15 | 90 | 44 | 20 | 6 | 5 | 2 |
| 16 | 91 | 47 | 23 | 7 | 5 | 2 |
| 17 | 92 | 51 | 26 | 9 | 6 | 2 |
| 18 | 93 | 56 | 32 | 9 | 6 | 2 |
| 19 | 94 | 61 | 34 | 12 | 6 | 2 |
| 20 | 94 | 65 | 34 | 14 | 6 | 2 |
| 21 | 94 | 67 | 36 | 17 | 7 | 2 |
| 22 | 94 | 71 | 42 | 19 | 8 | 2 |
| 23 | 94 | 74 | 45 | 20 | 10 | 2 |
| 24 | 94 | 77 | 48 | 21 | 12 | 3 |
| 25 | 94 | 79 | 50 | 21 | 13 | 3 |
| 26 | 95 | 80 | 53 | 24 | 14 | 4 |
| 27 | 95 | 82 | 55 | 27 | 15 | 4 |
| 28 | 95 | 84 | 59 | 31 | 17 | 5 |
| 29 | 96 | 87 | 63 | 36 | 20 | 6 |
| 30 | 97 | 88 | 64 | 40 | 23 | 6 |
| 31 | 97 | 90 | 66 | 44 | 27 | 6 |
| 32 | 97 | 92 | 67 | 47 | 31 | 8 |
| 33 | 98 | 93 | 68 | 49 | 34 | 9 |
| 34 | 98 | 94 | 70 | 53 | 37 | 9 |
| 35 | 99 | 95 | 73 | 57 | 39 | 12 |
| 36 | 99 | 96 | 78 | 59 | 40 | 13 |
| 37 | 99 | 96 | 81 | 62 | 41 | 15 |
| 38 | 100 | 97 | 84 | 64 | 41 | 15 |
| 39 | 100 | 98 | 86 | 66 | 45 | 17 |
| 40 | 100 | 98 | 88 | 71 | 50 | 19 |
| 41 | 100 | 99 | 89 | 75 | 54 | 23 |
| 42 | 100 | 99 | 92 | 79 | 56 | 29 |
| 43 | 100 | 100 | 95 | 81 | 61 | 36 |
| 44 | 100 | 100 | 96 | 84 | 67 | 40 |
| 45 | 100 | 100 | 97 | 88 | 71 | 44 |
| 46 | 100 | 100 | 98 | 93 | 76 | 56 |
| 47 | 100 | 100 | 98 | 95 | 79 | 65 |
| 48 | 100 | 100 | 99 | 98 | 85 | 71 |
| 49 | 100 | 100 | 100 | 100 | 91 | 78 |
| 50 | 100 | 100 | 100 | 100 | 98 | 89 |
| 51 | 100 | 100 | 100 | 100 | 99 | 94 |
| 52 | 100 | 100 | 100 | 100 | 100 | 100 |

(TABLE D-4, cont.)

| Score | Grade placement | | | | | |
|---|---|---|---|---|---|---|
| | 1.7 | 2.7 | 3.6 | 4.6 | 5.7 | 6.7 |
| | | | Subtraction | | | |
| 0 | 19 | 5 | 4 | 2 | 4 | 2 |
| 1 | 38 | 8 | 4 | 2 | 4 | 2 |
| 2 | 51 | 12 | 5 | 2 | 4 | 2 |
| 3 | 60 | 12 | 5 | 3 | 4 | 2 |
| 4 | 68 | 17 | 7 | 3 | 4 | 2 |
| 5 | 71 | 21 | 10 | 3 | 4 | 2 |
| 6 | 73 | 22 | 13 | 4 | 4 | 2 |
| 7 | 78 | 26 | 16 | 5 | 4 | 2 |
| 8 | 79 | 30 | 17 | 5 | 6 | 2 |
| 9 | 82 | 34 | 20 | 5 | 6 | 2 |
| 10 | 86 | 39 | 23 | 7 | 6 | 2 |
| 11 | 88 | 41 | 28 | 9 | 7 | 3 |
| 12 | 91 | 45 | 29 | 12 | 7 | 5 |
| 13 | 91 | 49 | 32 | 15 | 8 | 6 |
| 14 | 92 | 56 | 35 | 17 | 10 | 6 |
| 15 | 93 | 60 | 39 | 19 | 11 | 6 |
| 16 | 94 | 67 | 42 | 25 | 12 | 7 |
| 17 | 94 | 71 | 45 | 27 | 13 | 8 |
| 18 | 96 | 77 | 54 | 33 | 17 | 8 |
| 19 | 96 | 81 | 59 | 39 | 23 | 10 |
| 20 | 97 | 86 | 69 | 45 | 29 | 12 |
| 21 | 97 | 89 | 73 | 50 | 34 | 15 |
| 22 | 98 | 92 | 77 | 62 | 41 | 21 |
| 23 | 98 | 95 | 84 | 71 | 49 | 27 |
| 24 | 99 | 96 | 89 | 75 | 60 | 38 |
| 25 | 100 | 98 | 94 | 84 | 69 | 52 |
| 26 | 100 | 100 | 96 | 92 | 80 | 64 |
| 27 | 100 | 100 | 98 | 94 | 84 | 75 |
| 28 | 100 | 100 | 98 | 97 | 89 | 79 |
| 29 | 100 | 100 | 100 | 97 | 92 | 87 |
| 30 | 100 | 100 | 100 | 98 | 95 | 89 |
| 31 | 100 | 100 | 100 | 99 | 98 | 96 |
| 32 | 100 | 100 | 100 | 100 | 99 | 100 |
| 33 | 100 | 100 | 100 | 100 | 100 | 100 |

(TABLE D-4, cont.)

| Score | Grade placement | | | | | |
|---|---|---|---|---|---|---|
| | 1.7 | 2.7 | 3.6 | 4.6 | 5.7 | 6.7 |
| | Total test | | | | | |
| 0 | 5 | 3 | 3 | 2 | 4 | 2 |
| 1 | 12 | 3 | 3 | 2 | 4 | 2 |
| 2 | 16 | 3 | 3 | 2 | 4 | 2 |
| 3 | 20 | 3 | 3 | 2 | 4 | 2 |
| 4 | 27 | 4 | 4 | 2 | 4 | 2 |
| 5 | 30 | 4 | 4 | 2 | 4 | 2 |
| 6 | 39 | 4 | 4 | 2 | 4 | 2 |
| 7 | 41 | 4 | 4 | 2 | 4 | 2 |
| 8 | 45 | 5 | 4 | 2 | 4 | 2 |
| 9 | 48 | 5 | 4 | 2 | 4 | 2 |
| 10 | 52 | 6 | 4 | 2 | 4 | 2 |
| 11 | 52 | 7 | 4 | 2 | 4 | 2 |
| 12 | 55 | 7 | 4 | 2 | 4 | 2 |
| 13 | 58 | 8 | 4 | 2 | 4 | 2 |
| 14 | 61 | 9 | 4 | 2 | 4 | 2 |
| 15 | 63 | 10 | 4 | 2 | 4 | 2 |
| 16 | 65 | 12 | 5 | 2 | 4 | 2 |
| 17 | 66 | 12 | 5 | 2 | 4 | 2 |
| 18 | 68 | 13 | 5 | 2 | 4 | 2 |
| 19 | 71 | 15 | 6 | 2 | 4 | 2 |
| 20 | 72 | 15 | 6 | 2 | 4 | 2 |
| 21 | 74 | 16 | 6 | 2 | 4 | 2 |
| 22 | 76 | 18 | 6 | 2 | 4 | 2 |
| 23 | 79 | 19 | 7 | 2 | 4 | 2 |
| 24 | 81 | 20 | 8 | 2 | 4 | 2 |
| 25 | 81 | 21 | 9 | 3 | 4 | 2 |
| 26 | 83 | 22 | 10 | 3 | 4 | 2 |
| 27 | 83 | 24 | 11 | 3 | 4 | 2 |
| 28 | 83 | 26 | 12 | 3 | 4 | 2 |
| 29 | 84 | 27 | 15 | 3 | 4 | 2 |
| 30 | 87 | 29 | 15 | 3 | 4 | 2 |
| 31 | 87 | 32 | 15 | 3 | 5 | 2 |
| 32 | 88 | 32 | 17 | 3 | 5 | 2 |
| 33 | 89 | 34 | 18 | 3 | 5 | 2 |
| 34 | 89 | 36 | 19 | 3 | 6 | 2 |

(TABLE D-4, cont.)

| Score | Grade placement | | | | | |
|---|---|---|---|---|---|---|
| | 1.7 | 2.7 | 3.6 | 4.6 | 5.7 | 6.7 |
| 35 | 89 | 38 | 21 | 4 | 6 | 2 |
| 36 | 90 | 40 | 22 | 5 | 6 | 2 |
| 37 | 91 | 44 | 22 | 5 | 6 | 2 |
| 38 | 91 | 46 | 23 | 5 | 6 | 2 |
| 39 | 92 | 48 | 26 | 6 | 6 | 2 |
| 40 | 92 | 51 | 26 | 7 | 6 | 2 |
| 41 | 92 | 54 | 26 | 8 | 6 | 2 |
| 42 | 92 | 58 | 26 | 9 | 6 | 2 |
| 43 | 93 | 60 | 28 | 10 | 6 | 2 |
| 44 | 94 | 61 | 33 | 11 | 6 | 2 |
| 45 | 94 | 61 | 34 | 12 | 6 | 2 |
| 46 | 94 | 63 | 35 | 13 | 6 | 2 |
| 47 | 94 | 65 | 38 | 14 | 6 | 3 |
| 48 | 94 | 68 | 39 | 16 | 6 | 3 |
| 49 | 94 | 69 | 41 | 16 | 6 | 3 |
| 50 | 94 | 70 | 43 | 18 | 8 | 3 |
| 51 | 94 | 72 | 45 | 19 | 8 | 4 |
| 52 | 94 | 72 | 47 | 20 | 9 | 5 |
| 53 | 95 | 74 | 47 | 21 | 10 | 5 |
| 54 | 96 | 78 | 47 | 21 | 11 | 6 |
| 55 | 96 | 79 | 49 | 23 | 11 | 6 |
| 56 | 96 | 80 | 51 | 24 | 13 | 6 |
| 57 | 96 | 82 | 54 | 24 | 13 | 6 |
| 58 | 96 | 82 | 55 | 28 | 15 | 6 |
| 59 | 96 | 82 | 57 | 33 | 17 | 7 |
| 60 | 97 | 84 | 59 | 35 | 17 | 7 |
| 61 | 97 | 85 | 61 | 36 | 19 | 7 |
| 62 | 97 | 87 | 64 | 38 | 20 | 7 |
| 63 | 97 | 88 | 65 | 40 | 22 | 7 |
| 64 | 97 | 89 | 67 | 42 | 23 | 7 |
| 65 | 97 | 89 | 67 | 44 | 25 | 7 |
| 66 | 98 | 90 | 70 | 47 | 27 | 10 |
| 67 | 98 | 91 | 71 | 50 | 29 | 10 |
| 68 | 98 | 92 | 72 | 51 | 31 | 10 |
| 69 | 98 | 93 | 73 | 55 | 34 | 11 |

(TABLE D-4, cont.)

| Score | Grade placement | | | | | |
|---|---|---|---|---|---|---|
| | 1.7 | 2.7 | 3.6 | 4.6 | 5.7 | 6.7 |
| 70 | 98 | 94 | 77 | 58 | 34 | 13 |
| 71 | 99 | 95 | 78 | 61 | 35 | 13 |
| 72 | 99 | 95 | 79 | 61 | 37 | 13 |
| 73 | 99 | 95 | 82 | 64 | 41 | 14 |
| 74 | 99 | 96 | 84 | 66 | 43 | 16 |
| 75 | 99 | 97 | 84 | 68 | 46 | 16 |
| 76 | 100 | 98 | 85 | 68 | 48 | 17 |
| 77 | 100 | 98 | 87 | 70 | 48 | 18 |
| 78 | 100 | 99 | 89 | 73 | 51 | 19 |
| 79 | 100 | 99 | 90 | 75 | 55 | 24 |
| 80 | 100 | 99 | 92 | 80 | 56 | 29 |
| 81 | 100 | 100 | 94 | 81 | 59 | 31 |
| 82 | 100 | 100 | 95 | 83 | 61 | 35 |
| 83 | 100 | 100 | 96 | 83 | 65 | 37 |
| 84 | 100 | 100 | 97 | 84 | 68 | 41 |
| 85 | 100 | 100 | 97 | 88 | 70 | 47 |
| 86 | 100 | 100 | 98 | 92 | 73 | 52 |
| 87 | 100 | 100 | 98 | 93 | 77 | 56 |
| 88 | 100 | 100 | 99 | 94 | 78 | 60 |
| 89 | 100 | 100 | 99 | 96 | 80 | 68 |
| 90 | 100 | 100 | 99 | 96 | 85 | 74 |
| 91 | 100 | 100 | 99 | 97 | 91 | 81 |
| 92 | 100 | 100 | 100 | 99 | 94 | 85 |
| 93 | 100 | 100 | 100 | 99 | 95 | 88 |
| 94 | 100 | 100 | 100 | 100 | 96 | 91 |
| 95 | 100 | 100 | 100 | 100 | 98 | 93 |
| 96 | 100 | 100 | 100 | 100 | 99 | 94 |
| 97 | 100 | 100 | 100 | 100 | 99 | 95 |
| 98 | 100 | 100 | 100 | 100 | 100 | 99 |
| 99 | 100 | 100 | 100 | 100 | 100 | 100 |
| 100 | 100 | 100 | 100 | 100 | 100 | 100 |

## TABLE D–5

### Percentiles for Total Score by Age

| Score | Age |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 0 | 3 | 5 | 4 | 4 | 3 | 2 | 3 | 4 | 0 | 0 |
| 1 | 9 | 14 | 5 | 4 | 3 | 2 | 3 | 4 | 0 | 0 |
| 2 | 11 | 14 | 8 | 6 | 3 | 3 | 3 | 4 | 0 | 0 |
| 3 | 16 | 16 | 9 | 6 | 5 | 3 | 3 | 4 | 0 | 0 |
| 4 | 26 | 21 | 9 | 8 | 6 | 3 | 3 | 4 | 0 | 0 |
| 5 | 31 | 24 | 9 | 9 | 6 | 3 | 3 | 4 | 0 | 0 |
| 6 | 40 | 29 | 10 | 9 | 7 | 4 | 3 | 4 | 0 | 0 |
| 7 | 47 | 30 | 10 | 9 | 7 | 4 | 3 | 4 | 0 | 0 |
| 8 | 50 | 33 | 11 | 10 | 7 | 4 | 4 | 4 | 2 | 0 |
| 9 | 52 | 34 | 11 | 12 | 7 | 4 | 4 | 4 | 3 | 0 |
| 10 | 52 | 36 | 15 | 14 | 7 | 4 | 4 | 4 | 3 | 0 |
| 11 | 54 | 37 | 16 | 14 | 7 | 4 | 4 | 4 | 3 | 0 |
| 12 | 57 | 40 | 16 | 15 | 9 | 4 | 4 | 4 | 3 | 0 |
| 13 | 59 | 42 | 17 | 15 | 9 | 4 | 5 | 4 | 3 | 0 |
| 14 | 63 | 44 | 19 | 16 | 9 | 4 | 5 | 4 | 3 | 0 |
| 15 | 66 | 47 | 19 | 17 | 9 | 4 | 5 | 4 | 3 | 0 |
| 16 | 67 | 50 | 20 | 18 | 9 | 4 | 6 | 6 | 3 | 0 |
| 17 | 70 | 50 | 21 | 18 | 10 | 5 | 7 | 6 | 3 | 0 |
| 18 | 71 | 51 | 21 | 19 | 11 | 5 | 7 | 6 | 3 | 0 |
| 19 | 76 | 52 | 25 | 19 | 12 | 6 | 7 | 6 | 3 | 0 |
| 20 | 81 | 52 | 25 | 19 | 12 | 6 | 7 | 6 | 3 | 0 |
| 21 | 81 | 53 | 26 | 19 | 12 | 6 | 7 | 6 | 3 | 0 |
| 22 | 84 | 54 | 28 | 20 | 13 | 6 | 7 | 6 | 3 | 0 |
| 23 | 86 | 56 | 28 | 22 | 15 | 6 | 8 | 6 | 3 | 0 |
| 24 | 86 | 56 | 30 | 23 | 15 | 8 | 8 | 6 | 3 | 0 |
| 25 | 86 | 57 | 32 | 24 | 15 | 9 | 9 | 6 | 3 | 0 |
| 26 | 86 | 59 | 33 | 24 | 16 | 9 | 9 | 6 | 5 | 0 |
| 27 | 86 | 61 | 35 | 24 | 17 | 9 | 10 | 6 | 5 | 0 |
| 28 | 86 | 64 | 35 | 25 | 17 | 9 | 10 | 6 | 5 | 0 |
| 29 | 86 | 64 | 38 | 28 | 17 | 9 | 10 | 8 | 6 | 0 |
| 30 | 86 | 64 | 40 | 28 | 20 | 10 | 11 | 8 | 6 | 0 |
| 31 | 87 | 64 | 41 | 29 | 21 | 11 | 11 | 12 | 6 | 0 |
| 32 | 87 | 64 | 43 | 30 | 22 | 11 | 12 | 12 | 6 | 0 |
| 33 | 89 | 64 | 43 | 32 | 23 | 12 | 12 | 12 | 6 | 4 |
| 34 | 89 | 66 | 44 | 32 | 24 | 12 | 12 | 12 | 8 | 4 |
| 35 | 90 | 69 | 46 | 33 | 25 | 12 | 13 | 12 | 8 | 4 |

(TABLE D-5, cont.)

| Score | Age |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 36 | 90 | 69 | 47 | 35 | 26 | 14 | 14 | 12 | 8 | 4 |
| 37 | 91 | 72 | 48 | 36 | 27 | 14 | 15 | 12 | 8 | 4 |
| 38 | 91 | 72 | 48 | 38 | 28 | 14 | 15 | 13 | 8 | 4 |
| 39 | 93 | 73 | 51 | 40 | 29 | 15 | 16 | 13 | 8 | 4 |
| 40 | 93 | 74 | 53 | 40 | 31 | 16 | 17 | 13 | 8 | 9 |
| 41 | 94 | 74 | 54 | 41 | 32 | 19 | 18 | 14 | 10 | 9 |
| 42 | 94 | 75 | 54 | 43 | 32 | 20 | 18 | 14 | 10 | 9 |
| 43 | 94 | 75 | 57 | 44 | 33 | 21 | 18 | 16 | 11 | 9 |
| 44 | 94 | 80 | 59 | 47 | 34 | 21 | 18 | 16 | 11 | 9 |
| 45 | 94 | 82 | 59 | 48 | 34 | 22 | 18 | 16 | 13 | 9 |
| 46 | 94 | 83 | 59 | 50 | 34 | 23 | 18 | 16 | 13 | 9 |
| 47 | 94 | 84 | 59 | 52 | 36 | 24 | 19 | 17 | 16 | 9 |
| 48 | 94 | 85 | 61 | 54 | 38 | 24 | 21 | 18 | 16 | 9 |
| 49 | 94 | 85 | 62 | 54 | 40 | 26 | 21 | 18 | 16 | 13 |
| 50 | 94 | 85 | 64 | 55 | 40 | 28 | 22 | 22 | 16 | 13 |
| 51 | 94 | 85 | 66 | 57 | 42 | 29 | 23 | 22 | 16 | 13 |
| 52 | 94 | 85 | 66 | 58 | 42 | 30 | 24 | 24 | 17 | 13 |
| 53 | 96 | 85 | 66 | 60 | 42 | 31 | 26 | 25 | 17 | 13 |
| 54 | 97 | 85 | 69 | 61 | 43 | 33 | 27 | 28 | 17 | 13 |
| 55 | 97 | 86 | 71 | 62 | 44 | 34 | 27 | 29 | 19 | 13 |
| 56 | 97 | 86 | 74 | 62 | 45 | 35 | 28 | 30 | 19 | 17 |
| 57 | 97 | 87 | 74 | 64 | 46 | 35 | 28 | 33 | 21 | 17 |
| 58 | 97 | 87 | 77 | 65 | 47 | 36 | 30 | 35 | 22 | 17 |
| 59 | 97 | 87 | 79 | 66 | 50 | 36 | 31 | 37 | 24 | 17 |
| 60 | 99 | 88 | 79 | 68 | 51 | 38 | 33 | 37 | 24 | 17 |
| 61 | 99 | 89 | 81 | 69 | 51 | 39 | 33 | 37 | 24 | 17 |
| 62 | 99 | 89 | 83 | 70 | 54 | 41 | 35 | 37 | 27 | 17 |
| 63 | 99 | 89 | 85 | 72 | 55 | 44 | 36 | 37 | 29 | 17 |
| 64 | 99 | 90 | 85 | 72 | 58 | 45 | 38 | 37 | 32 | 17 |
| 65 | 99 | 91 | 86 | 72 | 59 | 46 | 38 | 40 | 32 | 17 |
| 66 | 99 | 91 | 88 | 75 | 60 | 49 | 38 | 41 | 33 | 26 |
| 67 | 99 | 93 | 88 | 75 | 62 | 49 | 41 | 43 | 35 | 26 |
| 68 | 99 | 94 | 89 | 76 | 62 | 52 | 41 | 43 | 35 | 26 |
| 69 | 99 | 94 | 90 | 77 | 64 | 54 | 44 | 46 | 37 | 30 |
| 70 | 99 | 95 | 92 | 79 | 65 | 56 | 46 | 49 | 37 | 30 |
| 71 | 99 | 96 | 92 | 81 | 67 | 59 | 47 | 51 | 37 | 30 |
| 72 | 99 | 96 | 92 | 81 | 68 | 59 | 48 | 52 | 38 | 30 |

(TABLE D–5, cont.)

| Score | Age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 73 | 99 | 96 | 93 | 82 | 70 | 61 | 51 | 53 | 40 | 30 |
| 74 | 99 | 96 | 93 | 83 | 73 | 63 | 54 | 53 | 41 | 39 |
| 75 | 99 | 96 | 93 | 85 | 76 | 65 | 54 | 55 | 41 | 39 |
| 76 | 99 | 96 | 93 | 85 | 77 | 67 | 57 | 55 | 41 | 39 |
| 77 | 99 | 96 | 94 | 86 | 78 | 69 | 58 | 57 | 41 | 39 |
| 78 | 99 | 96 | 94 | 88 | 79 | 72 | 60 | 57 | 50 | 39 |
| 79 | 99 | 96 | 97 | 88 | 79 | 74 | 61 | 58 | 57 | 48 |
| 80 | 99 | 97 | 98 | 91 | 82 | 76 | 64 | 59 | 57 | 48 |
| 81 | 99 | 97 | 98 | 93 | 84 | 78 | 65 | 60 | 59 | 52 |
| 82 | 99 | 98 | 98 | 94 | 85 | 79 | 68 | 63 | 62 | 57 |
| 83 | 99 | 98 | 98 | 95 | 85 | 79 | 70 | 65 | 65 | 57 |
| 84 | 99 | 98 | 98 | 95 | 85 | 80 | 73 | 66 | 71 | 70 |
| 85 | 99 | 98 | 98 | 95 | 86 | 86 | 75 | 69 | 73 | 70 |
| 86 | 100 | 98 | 98 | 96 | 88 | 89 | 79 | 72 | 76 | 70 |
| 87 | 100 | 98 | 99 | 97 | 90 | 90 | 82 | 72 | 76 | 74 |
| 88 | 100 | 98 | 99 | 98 | 90 | 91 | 85 | 76 | 76 | 74 |
| 89 | 100 | 99 | 99 | 98 | 93 | 92 | 88 | 82 | 81 | 74 |
| 90 | 100 | 99 | 99 | 99 | 95 | 93 | 89 | 86 | 83 | 87 |
| 91 | 100 | 99 | 99 | 99 | 97 | 95 | 92 | 90 | 89 | 91 |
| 92 | 100 | 100 | 99 | 99 | 97 | 98 | 94 | 92 | 94 | 91 |
| 93 | 100 | 100 | 99 | 99 | 97 | 98 | 96 | 92 | 97 | 91 |
| 94 | 100 | 100 | 99 | 100 | 97 | 98 | 97 | 98 | 97 | 91 |
| 95 | 100 | 100 | 99 | 100 | 99 | 99 | 98 | 98 | 97 | 96 |
| 96 | 100 | 100 | 100 | 100 | 99 | 99 | 99 | 98 | 98 | 96 |
| 97 | 100 | 100 | 100 | 100 | 99 | 99 | 99 | 98 | 98 | 100 |
| 98 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 100 | 100 |
| 99 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

## APPENDIX E

### PERFORMANCE OF FIRST- AND FIFTH-GRADE NICARAGUAN AND U.S. STUDENTS ON THE SMAT BY CONCEPT

| Item | Question | Percent correct | | | |
|---|---|---|---|---|---|
| | | Grade 1 | | Grade 5 | |
| | | Nic. | U.S. | Nic. | U.S. |
| | Number concepts | | | | |
| 1 | Write the number 1. | 86.6 | 98.6 | 94.9 | 100.0 |
| 2 | Which is bigger, 0 or 3? | 45.9 | 94.4 | 93.0 | 100.0 |
| 5 | Which is bigger, 9 or 6? | 19.9 | 79.0 | 91.8 | 100.0 |
| 6 | What comes between 0 and 2? | 11.3 | 69.9 | 87.3 | 100.0 |
| 7 | Write the number 17. | 30.3 | 77.6 | 91.8 | 100.0 |
| 8 | Which is bigger, 15 or 19? | 25.1 | 74.8 | 94.3 | 99.2 |
| 13 | Write the number 29. | 48.5 | 81.1 | 93.7 | 100.0 |
| 15 | Write the number 20. | 43.7 | 76.2 | 94.9 | 100.0 |
| 16 | What comes before 11? | 21.6 | 72.7 | 89.2 | 96.9 |
| 18 | Which is bigger, 84 or 27? | 25.5 | 44.8 | 93.0 | 97.1 |
| 19 | What comes between 16 and 18? | 13.0 | 53.1 | 83.5 | 98.1 |
| 20 | What comes between 6 and 8? | 15.2 | 60.8 | 89.2 | 99.7 |
| 21 | Which is bigger, 34 or 91? | 38.5 | 66.4 | 94.9 | 100.0 |
| 48 | Write the number 573. | 8.7 | 18.9 | 76.6 | 96.9 |
| 51 | What comes between 89 and 91? | 9.1 | 23.8 | 64.6 | 89.5 |
| | Addition | | | | |
| 3 | What is 3 plus 2? | 29.0 | 84.6 | 92.4 | 100.0 |
| 4 | 3 plus what equals 5? | 11.7 | 62.9 | 75.3 | 99.8 |
| 9 | 2 plus what equals 8? | 4.3 | 30.1 | 75.9 | 92.4 |
| 10 | What is 1 plus 2? | 33.3 | 81.1 | 95.6 | 100.0 |
| 11 | What is 10 plus 2? | 42.4 | 68.5 | 95.6 | 100.0 |
| 14 | What is 8 plus 0? | 22.9 | 74.8 | 86.1 | 99.2 |
| 17 | What plus 4 equals 7? | 6.1 | 42.0 | 79.7 | 96.4 |
| 22 | 0 plus what equals 2? | 19.0 | 55.9 | 73.4 | 99.1 |
| 24 | What is 6 plus 7? | 13.9 | 26.6 | 84.8 | 90.8 |
| 25 | What is 10 plus 9? | 23.8 | 34.3 | 94.3 | 98.6 |
| 26 | What is 1 plus 4? | 19.5 | 49.0 | 83.5 | 97.7 |
| 28 | 1 plus what equals 6? | 6.1 | 37.1 | 74.1 | 92.2 |
| 29 | What plus 6 equals 6? | 2.6 | 40.6 | 42.4 | 96.2 |
| 30 | What is 5 plus 10? | 35.9 | 46.2 | 91.1 | 97.4 |
| 32 | 3 plus what equals 13? | 10.8 | 36.4 | 41.8 | 94.7 |
| 33 | 3 plus what equals 10? | 8.2 | 26.6 | 79.7 | 99.2 |
| 34 | What is 2 plus 1 plus 5? | 20.3 | 33.6 | 82.9 | 93.7 |

| Item | Question | Percent correct | | | |
|---|---|---|---|---|---|
| | | Grade 1 | | Grade 5 | |
| | | Nic. | U.S. | Nic. | U.S. |
| 35 | What is 11 plus 3? | 27.7 | 34.3 | 91.1 | 99.2 |
| 36 | What is 8 plus 9? | 22.5 | 18.9 | 89.2 | 97.7 |
| 38 | What plus 10 equals 12? | 8.7 | 42.0 | 69.6 | 97.7 |
| 41 | What plus 6 equals 14? | 10.0 | 12.6 | 82.9 | 82.3 |
| 43 | 9 plus what equals 17? | 5.6 | 18.2 | 72.2 | 92.7 |
| 44 | What plus 10 equals 19? | 12.6 | 32.9 | 77.2 | 96.9 |
| 45 | 8 plus what equals 28? | 7.8 | 8.4 | 65.2 | 78.5 |
| 47 | What is 5 plus 12? | 22.1 | 13.3 | 77.8 | 96.9 |
| 49 | 12 plus what equals 14? | 7.4 | 9.1 | 81.6 | 89.3 |
| 50 | What is 91 plus 7? | 12.1 | 14.0 | 83.5 | 97.7 |
| 52 | What is 10 plus 70? | 18.6 | 19.6 | 84.8 | 95.4 |
| 54 | What plus 13 equals 14? | 7.8 | 30.1 | 75.9 | 93.1 |
| 55 | What is 20 plus 70? | 13.9 | 14.0 | 82.3 | 83.4 |
| 57 | 3 plus what equals 15? | 5.2 | 4.9 | 70.3 | 74.2 |
| 60 | What is 5 plus 32? | 17.7 | 14.7 | 84.2 | 87.0 |
| 61 | What plus 70 equals 75? | 15.2 | 23.8 | 75.3 | 97.7 |
| 67 | What is 2 plus 336? | 3.0 | 4.2 | 65.2 | 71.0 |
| 68 | What plus 13 equals 16? | 5.2 | 14.7 | 74.1 | 87.8 |
| 71 | What is 4 plus 17? | 32.9 | 20.3 | 87.3 | 87.5 |
| 72 | What plus 10 equals 80? | 6.5 | 11.2 | 70.9 | 89.3 |
| 73 | What is 38 plus 9? | 7.8 | 1.4 | 64.6 | 81.7 |
| 75 | What plus 30 equals 40? | 10.4 | 15.4 | 73.4 | 85.5 |
| 78 | What plus 40 equals 90? | 4.3 | 13.3 | 70.9 | 82.9 |
| 79 | What plus 2 equals 48? | .9 | 4.9 | 51.9 | 74.2 |
| 81 | What is 9 plus 36? | 10.4 | 11.9 | 69.6 | 81.7 |
| 84 | What plus 86 equals 89? | 6.5 | 7.0 | 60.8 | 76.9 |
| 86 | What is 34 plus 35? | 4.8 | 5.6 | 63.3 | 72.5 |
| 88 | 50 plus what equals 130? | 1.7 | .7 | 39.2 | 65.9 |
| 90 | What is 6 plus 5 plus 8? | 10.0 | 8.4 | 69.0 | 83.2 |
| 91 | What is 9 plus 4 plus 8? | 12.1 | 9.8 | 72.8 | 81.7 |
| 92 | 6 plus 5 equals 10 plus what? | 3.5 | 3.5 | 29.7 | 54.9 |
| 94 | What is 93 plus 700? | 1.3 | 4.2 | 58.2 | 67.9 |
| 95 | 43 plus what equals 73? | 1.7 | 0 | 31.6 | 46.6 |
| 96 | 4 plus what equals 57? | .9 | 0 | 39.2 | 62.8 |
| 100 | What is 400 plus 25? | 3.0 | 7.0 | 76.6 | 84.7 |
| | Subtraction | | | | |
| 12 | What is 5 take away 2? | 32.5 | 75.5 | 96.2 | 100.0 |
| 23 | What is 7 take away 4? | 25.1 | 49.7 | 92.4 | 98.8 |
| 27 | 4 take away what equals 2? | 13.9 | 46.9 | 86.1 | 97.6 |
| 31 | What is 8 take away 4? | 39.0 | 56.6 | 93.0 | 98.5 |
| 37 | What is 12 take away 2? | 20.3 | 40.6 | 91.8 | 97.7 |
| 39 | What is 10 take away 9? | 27.7 | 48.3 | 93[illegible] | 99.2 |

| Item | Question | Percent correct | | | |
|---|---|---|---|---|---|
| | | Grade 1 | | Grade 5 | |
| | | Nic. | U.S. | Nic. | U.S. |
| 40 | 3 take away what equals 2? | 13.4 | 45.5 | 81.6 | 97.2 |
| 42 | What is 17 take away 7? | 16.5 | 30.1 | 81.0 | 96.2 |
| 46 | What is 13 take away 10? | 19.5 | 24.5 | 88.6 | 98.5 |
| 53 | What is 12 take away 7? | 9.5 | 14.7 | 79.7 | 92.3 |
| 56 | What is 75 take away 5? | 16.5 | 23.1 | 76.6 | 88.5 |
| 58 | What take away 3 equals 2? | 10.8 | 6.3 | 13.9 | 79.4 |
| 59 | 16 take away what equals 6? | 5.6 | 12.6 | 70.3 | 79.7 |
| 62 | What is 13 take away 2? | 20.8 | 25.2 | 89.9 | 90.2 |
| 63 | What is 80 take away 10? | 16.5 | 18.2 | 88.6 | 95.0 |
| 64 | What is 19 take away 10? | 18.2 | 18.2 | 88.0 | 86.2 |
| 65 | What is 12 take away 11? | 17.7 | 30.1 | 89.2 | 96.9 |
| 66 | What is 16 take away 4? | 8.2 | 12.6 | 80.4 | 90.8 |
| 69 | What is 90 take away 80? | 12.1 | 15.4 | 83.5 | 91.6 |
| 70 | What is 55 take away 50? | 24.7 | 14.7 | 88.0 | 87.4 |
| 74 | 59 take away what equals 9? | 4.3 | 2.1 | 60.8 | 69.4 |
| 76 | What take away 7 equals 2? | 10.4 | 2.8 | 11.4 | 70.8 |
| 77 | What is 15 take away 7? | 7.4 | 7.0 | 73.4 | 76.9 |
| 80 | 7 take away 0 equals 8 take away what? | 2.6 | 5.6 | 27.2 | 53.8 |
| 82 | 16 take away what equals 8? | 27.3 | 9.1 | 74.1 | 79.2 |
| 83 | What take away 5 equals 1? | 10.4 | 4.9 | 15.8 | 26.3 |
| 85 | What take away 4 equals 10? | 3.9 | 6.3 | 17.1 | 58.8 |
| 87 | 90 take away what equals 20? | 4.3 | 4.2 | 57.0 | 73.1 |
| 89 | What is 80 take away 30? | 11.3 | 7.7 | 70.3 | 84.7 |
| 93 | 13 take away what equals 2? | 6.1 | 6.3 | 62.7 | 69.5 |
| 97 | What is 120 take away 40? | 6.1 | 2.8 | 65.2 | 59.5 |
| 98 | What take away 9 equals 10? | 6.1 | 4.2 | 15.2 | 73.1 |
| 99 | What take away 10 equals 2? | 5.6 | 4.2 | 15.8 | 17.6 |

# INDEX

*Page numbers in italics refer to the reference lists at the ends of the chapters.*

Ability group, 192–193
Ability grouping, 191
Achievement
  correlation, with classroom variables, 193
  determinants of, 207, 210
  in mathematics, 32, 107–112, 207–209, 303–304
  measurement of, 102
  and promotion, 209
  relation to dropout, 243–247, 255
  relation to promotion, 243–247, 255
  relation to repetition, 243–247, 255
  and repetition, 209
Active responding, 10–12, 178, 179, 189
Addition
  oral, 13, 305–306
  test results for, 28, 31
  test scores for, 305–306
Age
  changes in test scores, with grade, 311
  relation to dropout, 239–241
  relation to promotion, 239–241
  relation to repetition, 239–241
  of students, 311
  of teacher, 146, 229
Age-equivalent scores, 304
Albert, L. R., 1
Alexander, L., 208, *220*
Attendance
  determinants of, 213
  relation to achievement, 209
  relation to dropout, 242–243
  relation to failure, 211
  relation to promotion, 242–243
  relation to repetition, 242
  of students, 212
Attitudes
  of teacher, 143

Battery costs, 280, 285–295
Beirn, R., 200, *219*
Berlinger, D. C., 180, *196*
Borrowing in subtraction, 130
Boruch, R. F., 101, 102, *118*
Bower, G., 179, *196*

Canonical exercise format, 306
Carnoy, M., 209, *219*
Chu, G., 179, *196*
Class size
  relation to achievement, 209
Classroom behavior
  of students, 178
  of teacher, 178, 190
Classroom observations, 9
Concrete materials, 179–180, 187, 188
Cost methodology, 267–268
Costs
  of batteries, 280, 285–295
  effect of implementation on, 7, 32, 284–296
  of program, 274–276
  of program production, 274–276
  of radio instruction, 216
  of radio transmission, 277–278
  of reception, 278–279
  of teacher's guides, 278
  of traditional instruction, 216
Curriculum, 126
  for Grade 1, 98
  for Grade 2, 12
  for master plan, 15
  Ministry of Education, 12–13
Curriculum development
  cost implications of, 297
Curriculum revision
  cost implications of, 274

Delayed oral response, 10, 11, 23
Dialogue
  instructional, 10–11
Dropout, 223, 265
  between year, 233, 235
  determinants of, 214
  patterns of, 232, 234, 236
  rate, 271
  relation to achievement, 243–247, 255
  relation to age, 239–241
  relation to attendance, 242–243
  in relation to repetition history, 238
  within year, 212, 233, 235

Education production function, 204, 208
Educational system in Nicaragua, 265
Entertainment
  stories as, 26
  time devoted to, 183–184
Entertainment segment
  jokes in, 24–26
  songs in, 24–26
Evaluation
  formative, 125
  of Grade 1, 97
  of Grade 2, 27
  of radio lessons, 200–203
  summative, 27, 97, 201, 272
Evaluation results
  for Grade 2, 27–28
Exercise class, 128
  definition of, 13
  for Grade 2, 13

Experimental design, 27, 101–102

Failure
  determinants of, 202, 208–211
Feedback, 9, 34, 125
  use of, 133
Folks, G., 212, *219*
Formative evaluation, 125
Friend, J., 1, 2, *6*, 7, 27, *35*, 97, *118*, 201, *220*, 226, 253, *261*

G item, 103, 126, 128
Gage, N. L., 180, *196*
Galda, K., 3, 125
George, E., 4, 207, 223
Ginsberg, R., 179, *197*
González, J., 1, 4, 207, 223
Grade
  changes in test scores with, 307–308
Grade-equivalent scores, 304
Guadamuz, N., 2, 7

Haddad, W., 209, *219*
Harnischfeger, A., 209, *221*

I item, 103, 126, 128
Implementation, effect on costs, 269, 284–296
Inkeles, A., 178, *196*
Innovation, 181
Instructional dialogue, 10–11
Instructional strategy, 12

Jallade, J. P, 200, *220*
Jamison, D., 4, 199, 200, 207, 208, 209, 216, 218, *220*, 223, 249, 268, *299*
Jokes in entertainment segment, 24–26

Key prerequisite, 19, 128
Kinsey, D. C., 200, *219*
Klees, S., 5, 263, 268, *299*
Knowledge of results, 12, 179, 186
Kohn, M., 205, *220*

Lau, L. J., 200, 204, 208, *220*
Leslie, J., 218, *220*
Lesson production schedule, 9
Lesson segment, 20
Lethem, F., 219, *220*
Levy, M., 213, 219, *220*
Likert scale, 145, 158
Logit model, 205

Master curriculum plan for Grade 2, 15
Mathematics program (traditional), 100
Matrix sampling, 28, 103, 104, 105–106, 126
Matthews, P., 2, 97
Maynard, R., 212, *220*
McAnany, E., 216, *220*
McGinn, N. F., 200, *219*
McNally, K., 207, *220*
Montenegro, J. J., 2, 7
Morningstar, M., 22, 306, 307, *320*
Multiplication, test results for, 31
Municipal schools, 303
Murname, R., 212, *220*

Nicaragua, educational system in, 265
Noncanonical exercise format, 306, 307
Number concepts, test scores for, 304
Numeration, test scores for, 304

Olshen, J. S., 301, 303, 315, *320*
Oral addition, 13
  test scores for, 305–306
Oral responses, 10, 23–24
Oral subtraction, test scores for, 306–307

Pacing, 180
Palmer, E. L., 180, *196*
Pauses, 35
Population, school–age, 271
Posttest
  for Grade 1, 103
  for Grade 2, 27
Praise, 180, 187
Prerequisite, key, 19, 128
Pretest for Grade 1, 102, 107–108
Production function, use in education, 204, 208
Program production costs, 274–276
Promotion
  criteria for, 224–225
  patterns of, 232, 234, 236
  relation to achievement, 243–247, 255
  relation to age, 239–241
  relation to attendance, 242–243
  in relation to repetition history, 238
Psychological principles
  active responding, 10–12, 179
  knowledge of results, 12, 179, 186
  use in radio lessons, 179, 192

Quintanilla, A. de, 3, 125

Radio
  dialogue, 10–11
  model of effect on wastage, 202
Radio lessons
  advantages of, 149
  characteristics of, 179–181, 183–190
  disadvantages of, 149–150
  effect on achievement, 28, 31, 209, 257
  effect on wastage, 217
  evaluation of, 194
  evolution of, 194–195
  length of, 183
  teacher attitudes towards, 149–151, 153
  teacher behavior during, 178
  use, 114–115, 148–149, 160
  use of psychological principles in, 10–12, 179, 192
Radio transmission
  costs, 277–278, 297–298
  facilities for, 270
Randomized field experiment, 101
Reavis, G. H., 212, *220*
Reception costs, 278–279
Regression analyses, 106, 204, 249

  logit model in, 205
Repeaters, flow outcomes for, 237
Repetition, 199–200, 223, 265
  determinants of, 209
  patterns of, 232, 234, 236
  relation to achievement, 243–247, 255
  relation to age, 239–241
  relation to attendance, 242–243
  in relation to repetition history, 238
Responses
  delayed oral, 10, 23
  by students, 10, 23
  physical, 10
  written, 10, 23
Results
  of addition test, 30
  of evaluation for Grade 2, 27–28
  knowledge of, 179, 186
  of multiplication test, 31
  of subtraction test, 31
Revision of curriculum, 9–10, 274
Riecken, H. W., 101, *118*
Robinson, B., 212, *220*, 259, *261*
Rogers, E. M., 181, *196*
Rural schools, 227–228, 240, 242, 244, 246, 248, 265–266, 303
  effect of radio lessons in, 110, 114

Sachar, J., 5, 301; *see also* Olshen.
Sack, R., 209, *220*
School-age population, 271
School location, relation to achievement, 246
Schools
  characteristics of, 202, 206
  municipal, 303
  rural, 227–228, 240, 242, 244, 246, 248, 303
  urban, 227–228, 240, 242, 244, 246, 248, 303
Schramm, W., 179, *196*
Scores
  for addition test, 305–306
  age-equivalent, 304
  changes in test, with age, 311
  changes in test, with grade, 307–308
  for numeration test, 304
  for oral addition test, 305–306
  for oral subtraction test, 306–307
Searle, B., 1, 2, 3, 4, *6*, 7, 27, 28, *35*, 97, 102, 103, *118*, 143, 201, 205, 207, *220*, 223, 226, 253, 255, *261*
Segments
  entertainment, 24
  instructional, 20
  lesson, 20
Sheehan, J., 4, 207, 223
Shoemaker, D., 103, *118*
Shoemaker, F. F., 181, *196*
Shortlidge, R. L., 212, *220*
Simmons, J., 208, *220*
Sirotnik, K., 28, *35*, 108, *118*
SMAT, 301
  Spanish version of, 302
Songs, 24–26
Staffing patterns
  cost implications of, 296–297
  of project, 274
  in schools, 279
Stanford Mental Arithmetic Test, 301
Stolurow, L. M., 179, *197*
Stories as entertainment, 26
Strands
  definition of, 13
  in Grade 2, 13
Students
  characteristics of, 202, 206, 231, 239
  classroom behavior of, 178
Subtraction, 130
  curriculum, 17–18
  oral, 306–307
  test results for, 28, 31
  test scores for, 306–307
Supervision, 99
Suppes, P., 1, 2, *6*, 7, 27, *35*, 97, *118*, 179, *197*, 201, 208, *220*, 226, 253, *261*, 306, 307, *320*

Teacher
  age of, 146, 229–230
  attitudes of, 143
  attitudes towards radio lessons, 149–151, 153
  behavior during radio lessons, 178
  characteristics of, 159–161
  classroom behavior of, 178, 190
  education of, 146–147, 228–230
  experience of, 146, 230
  interviews of, 144
  sex of, 146
  training of, 98
Teacher's guides, 99
  cost of, 278, 285–295
  mathematics content, 21
Teacher questionnaire, 143
  administration of, 145
Test administration, 104, 126
Test of Basic Experiences, 102
Test scores
  changes in, with age, 311
  changes in, with grade, 307–308
Thias, H., 209, *219*
Tilson, T., 3, 27, *35*, 143, 177, 278, 279
Time
  devoted to entertainment, 183–184
  instructional, 180, 184, 186
TOBE, 102
Traditional instruction, 178, 190–193, 224, 255
  in mathematics, 100

Urban schools, 227–228, 240, 242, 244, 246, 248, 303
  effect of radio lessons in, 110, 114

Vrooman, V., 2, 7

Wastage, 223, 265
  definition, 199
  determinants of, 208, 209–213
  model of radio's effect on, 202
  of students, 199

Weekly tests, 9, 125
Wells, S., 5, 204, 208, *220*, 263, 268, *299*
Wiley, D. E., 209, *221*
Wolff, L., 199, *221*
Worksheets, 32
Written responses, 10, 23

Ziegler, C. W., 209, *221*